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B.Sc. 1st SEMESTER
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COURSE TITLE AND CODE : NON-CHORDATA (ZO (N) 101
ISBN : 978-93-85740-53-4

EDITION : 2023
PUBLISHED BY : UTTARAKHAND OPEN UNIVERSITY, HALDWANI, NAINITAL (263139)

ZO (N) 101

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COURSE: LABORATORY COURSE

COURSE CODE: ZO (N) 101 L

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COURSE TITLE AND CODE	**: LABORATORY COURSE, ZO (N) 101 L**
ISBN	**: 978-93-85740-56-5**
COPYRIGHT	**: UTTARAKHAND OPEN UNIVERSITY**
EDITION	**: 2023**
PUBLISHED BY	**: UTTARAKHAND OPEN UNIVERSITY, HALDWANI, NAINITAL- 263139**

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COURSE: LABORATORY COURSE

COURSE CODE: ZO (N) 101 L **CREDITS: 1**

UNIT: 01 PHYLUM-PROTOZOA

1.1 Objectives:

- To study General characters of Phylum Protozoa and its classification up to order.
- Study of *Paramecium* with particular reference to locomotion, Osmoregulation and reproduction.

1.2 Introduction

The Protozoa are heterogeneous assemblage of some 50,000 cellular or single- cell organism found worldwide in most habitats. Protozoa means ‘first animal’ the simplest form of animal life. Protozoa are unicellular microorganisms (eukaryotes) that lack cell walls. They are found in marine habitat or soil, in fresh water bodies, symbiotic, some forms are parasites in other organisms. Protozoa depends on nutrition, temperature, pH, and some depends on sunlight.

Protozoa were defined as unicellular protists with animal-like behavior, such as movement. Protozoa were regarded as the partner group of protists to protophyta, which have plant-like behavior, e.g. photosynthesis. The term protozoan has become highly problematic due to the introduction of modern ultra structural, biochemical, and genetic techniques, which have showed that the group does not form a clade as required by modern classifications. Modern unicellular clades within Eukaryotes which may be viewed as approximately collectively replacing the class of protozoa include: *Excavata, Amoeba, Chromalveolata* and *Rhizaria*.

Protozoans are usually single-celled heterotrophic eukaryotes containing non-filamentous structures that belong to any of the major lineages of protists. They are restricted to moist or aquatic habitats (i.e., they are obligate aquatic organisms). Many protozoan species are symbionts, some are parasites, and some are predators of feces bacteria and algae. There are an estimated 50,000 protozoan species.

The Protozoa are considered to be a subkingdom of the kingdom Protista, although in the classical system they were placed in the kingdom Animalia. More than 50,000 species have been described, most of which are free-living organisms; protozoa are found in almost every possible habitat. The fossil record in the form of shells in sedimentary rocks shows that protozoa were present in the Pre-Cambrian era. Anton van Leeuwenhoek was the first person to see protozoa, using microscopes he constructed with simple lenses. Between 1674 and 1716, he described, in addition to free-living protozoa, several parasitic species from animals, and *Giardia lamblia* from his own stools.

1.3 General characters and classification

General Characters of protozoa

- They are aquatic (fresh and salt water) free living parasitic, symbiotic or commensally. Usually microscopic with oval, elongated, spherical or ever changing shape
- They show cellular level of organization, where all the activities of the body are performed by a single cell.
- The protozoan cell body is either naked or surrounded by a non rigid pellicle. Cellulose is absent in the pellicle.
- Some protozoans secrete shells of various inorganic compounds as external covers.
- They possess different types of locomotory organs.
- They may bear flagella (flagellates), cilia (ciliates) or pseudopodia (scorodines).
- Locomotory organs are absent in the parasitic forms.
- They are holozoic (animal-like) and feed largely on bacteria, microscopic algae and minute animals such as rotifers or on other protozoan's including members of their own species.
- Some are holophytic (plant-like); they contain chlorophyll and prepare their own food by photosynthesis (Euglena).
- The parasitic protozoans devour on materials obtained from the hosts (Monocystis).
- Some are saprozoic (subsisting on dead organic matter) and saprophytic (feeding on liquid food).
- The osmotic concentration of cell body (Osmoregulation) is maintained by one or more contractile vacuoles and these contractile vacuoles are help in excretion.
- The excretory product is ammonia.
- Asexual reproduction takes place by binary fission or budding.
- Sexual reproduction is performed by the fusion of gametes or by conjugation.

  Examples:

Free living- *Euglena* (Fig.1), *Amoeba* (Fig.2), *Noctiluca* (Fig.3), *Paramecium* (Fig.4), *Elphidium* (Polystomella)

Parasitic-*Monocystis*, *Entamoeba*, *Giardia* (Fig.5), *Plasmodium* (Fig.6), *Trypanosome*, etc

- The single cell of the body performs all the vital activities.
- Encystment occurs to tide over the unfavorable conditions and to help in the dispersal of race.
- In certain animalcules, the life cycle is complicated and exhibits alternation of generations.

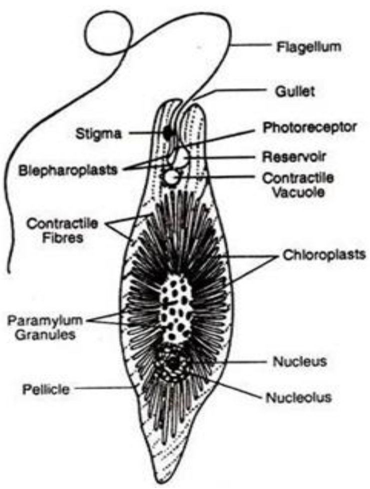

Fig.1.1Euglena

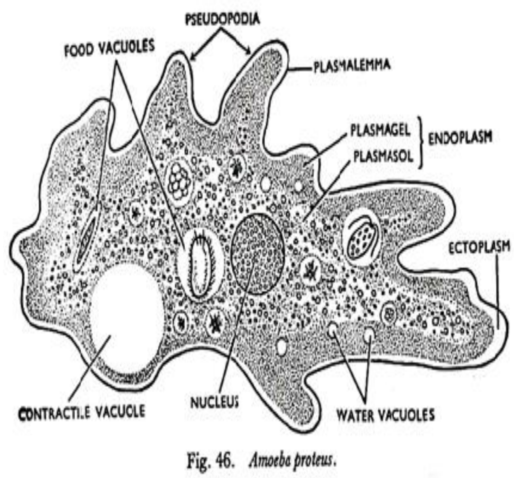

Fig.1.2 *Amoeba*

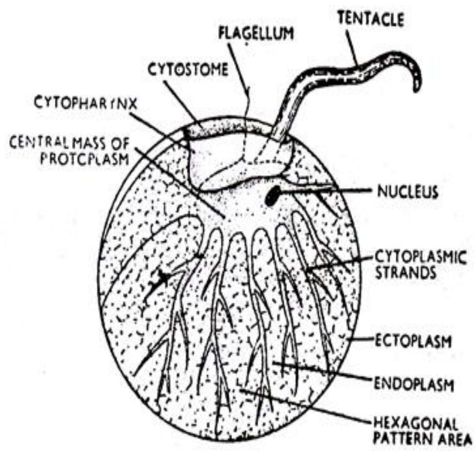

Fig.1.3 Noctiluca

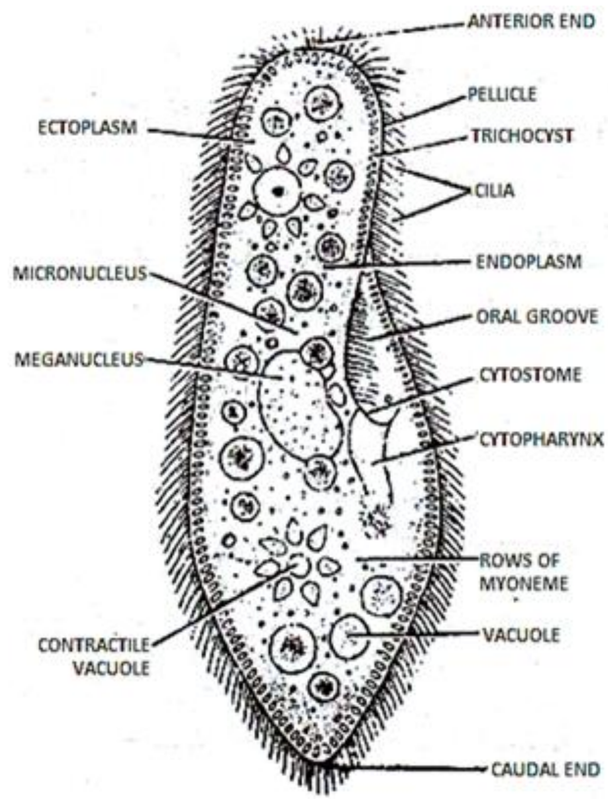

Fig.1.4: *Paramecium*

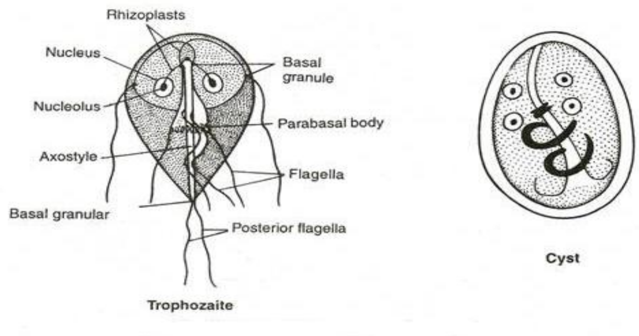

Fig.1.5 Giardia

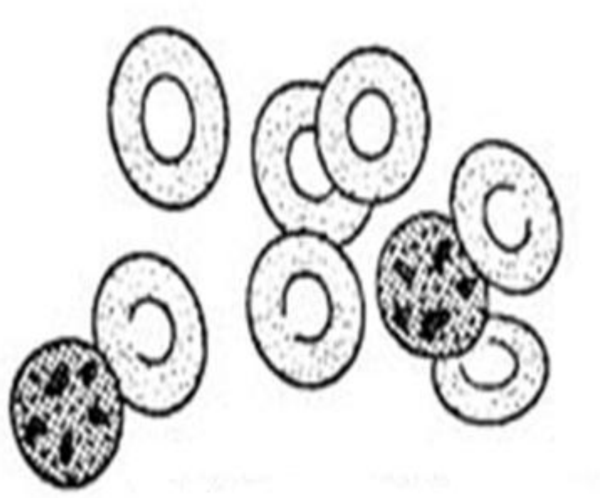

Fig.1.6: *Plasmodium (In Red Blood Cells)*

1.3.1 Distribution

Habit and habitat:

Paramecium is occurrence in fresh water ponds, lakes, rivers and streams. It is also found in abundance in stagnant water bodies.

Shape and size:

Pellicle:

The body is covered by a thin firm but elastic pellicle. Pellicle consists of three membranes.

a)-The outer or surface membrane is continuous with the membrane surrounding the cilia.

b)-The outer and inner membranes of the alveoli thus form the middle and inner membranes of the pellicle.

Cilia:

The entire body surface is covered by a uniform covering of hair like protoplasmic processes, the cilia.

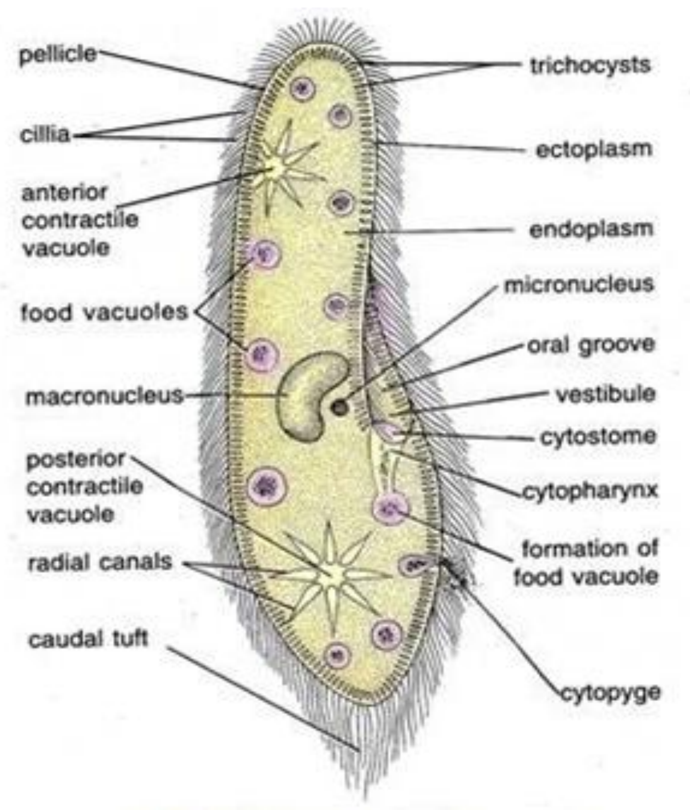

Fig.1.7. Paramecium Caudatum

Paramecium is unicellular microscopic organism. Its size varies in different species being 120-250μ in *P. Aurelia* and 170-290μ in *P. Caudatum.* It is commonly known as slipper animalcule. Its body is asymmetrical with flat oral and a convex aboral or dorsal surface.

Oral apparatus:

In Paramecium, there is a broad, shallow oral groove on the ventral surface. The oral groove extends obliquely backwards into a conical funnel shaped depression called vestibule. It leads into the buccal cavity followed by narrow cytopharynx through narrow apertures, the Cytosomes. Cytopharynax at its proximal end formed food vacuoles. Buccal cavity, at its right side is bordered by a row of cilia forming endoral membrane. At left side are the three groups of 4 rows of cilia. These are ventral peniculus, dorsal peniculus and quadrulus. From endoral membrane ribbed pellicles extends up to cytostome. Nemedesmal fibres are present in the cytostome & Cytopharynx.

1.3.2- Classification of Protozoa

Phylum protozoan's are a larger and varied group and possess a number of problems in its classification. The conventional scheme followed by Hyman (1940), Hickman (1961) and Store (1965) etc. recognizes two subphyla on the basis of organs of locomotion and 5 classes , briefly outlined as follows:

Subphylum A. Plasmodroma

- Locomotory organelles are flagella, pseudopodia, or none.
- Nuclei of one kind.

Class-1-Mastigophora:

- Move by one too many flagella.

  E.g. Euglena.

Class-2-Sarcodina:

- Move and capture food by pseudopodia.

  E.g. Amoeba.

Class-3- Sporozoa

- No locomotory organs.
- All Parasitic.

  E.g. Plasmodium.

Subphylum B. Ciliophora

- Cilia or sucking tentacles throughout or at certain stages.
- Nuclei of 2 kinds.

Class-4-Ciliata

- Move by cilia

  E.g. Paramecium

Class-5-Suctoria

- Move by cilia as young stage and by tentacles as adult stage.

  Eg. Podophyra.

The following classification of Protozoa is based on the scheme given by the committee on Taxonomy and Taxonomic Problems of the society of Protozoologists, and mainly proposed by B. M. Honigberg and others (1964).

Phylum Protozoa has been classified into four sub-phylum:-

Sub-phylum 1. Sarcomastigophora

Sub-phylum 2. Sporozoa

Sub-phylum 3. Cnidospora

Sub-phylum 4. Ciliophora

Sub-phylum1. Sarcomastigophora

1. Locomotors organelles pseudopodia or flagella or both.
2. Nucleus one or more and of the same kind.
3. Asexual reproduction by binary and multiple fission.

Superclass (A) - Mastigophora (Flagellata)

1. Simple, primitive and with firm pellic.
2. Locomotor organelles flagella.
3. Nutrition autotrophic or heterotrophic.

Class- 1. Phytomastigophora (Phytoflagellata)

1. Chlorophyll bearing chromatophores present.
2. Nutrition holophytic or photophytic.
3. Flagella 1 or 2 or many.

Order- 1. Chrysomonadida

1. Amoeboid forms without gullet but with stigma.
2. Flagella usually 1, sometimes 2 or 3.
3. Chromatophores 1 or 2, yellowish or brownish or yellowish green.
4. Starch absent but leucosin and fats may be present.

5. Siliceous cyst.
6. Marine or freshwater animals.

   Eg. *Chrysamoeba, Dinobryon*

Order- 2. Cryptomonadida

1. Anterior gullet reaches upto the middle of the body.
2. Flagella 2 and unequal.
3. Chromatophores 2, yellow, brown, colourless.
4. Reserve food starch.
5. Stigma present.
6. Marine or freshwater.

   Eg. *Chilomonas, Crytomonas.*

Order- 3. Euglenida;

1. Anterior end with a gullet or cytophyarynx leading into a reservoir.
2. Flagella 1 or 2, and with mastigonemes.
3. Chromatophores numerous and green.
4. Mostly freshwater.

   Eg. *Euglena*, *Peranema*.

Order- 4. Volvocida (Phytomonadida)

1. Small with rigid cellulose covering and no gullet.
2. Flagella usually 2, sometimes more.
3. Reserve foodstuff starch and oils.
4. Stigma present,
5. Mostly freshwater, some from colonies.

   E.g. *Chlamydomonas*, *Volvox*.

Order- 5. Chloromonadida

1. Dorso-ventrally flattened forms with delicate pellicle.
2. Flagella 2, sometimes 1 or more.

3. Chromatophores green and numerous, some colourless.
4. Reserve foodstuff oil.
5. No stigma.
6. Large freshwater.

   E.g. *Coelomonas.*

Order- 6. Dinoflagellida

1. Small and planktonic, naked and amoeboid or with a thick pellicle or theca.
2. Flagella two.
3. Chromatophores numerous, yellow or brown.
4. Reserve food starch or oil or both.
5. Stigma present; contractile vacuoles two.
6. Some are bioluminescent.
7. Largely marine.

   E.g. Noctiluca, *Ceratium*, *Gymnodinium*.

Class-2. Zomastigophorea (Zooflagellata)

1. Chlorophyll or chromatophores absent.
2. Nutrition holozoic or saprozoic.
3. Parasitic, symbiotic or free living.
4. Reserve food glycogen.
5. Flagella one or many.

Order-1. Rhizomastigida

1. Small and amoeboid.
2. Flagella one or four.
3. Locomotion by flagella or pseudopodia.
4. Chiefly fresh water.

   E.g. *Mastigamoeba, Dimorpha*.

Order-2. Kinetoplastida

1. Small and more or less amoeboid in form.
2. Flagella 1 or 2.
3. Holozoic or saprozoic nutrition.
4. Solitary or colonial.
5. Parasitic forms living in blood.

   Eg. *Leishmania*, *Trypanosoma.*

Order- 3. Choanoflagellida

1. Free living.
2. Colonial
3. A collar around the base of a single flagellum.
4. Nutrition holozoic.

   Eg. *Proterospongia*.

Order- 4. Diplomonadida

1. Flagella 3 or 8, one forming the border of undulating membrane.
2. Uninucleate, sometimes multinucleate.
3. Mostly intestinal parasites.

   E.g. Giardia, Hexamita.

Order- 5. Hypermastigida

1. Highly specialized forms with numerous flagella.
2. Kinetosomes or parabasal bodies arranged in a circle or longitudinal or spiral rows.
3. Uninucleate or multinucleate.
4. Mouth absent, food ingested by pseudopodia.
5. Gut parasites of termites and cockroaches.

   Eg. *Trychonympha, Lophomonas*.

Order-6. Trichomonadida

1. Flagella 4-6.
2. One flagellum trailing.
3. Parasites in genital passage.

   Eg. *Trichomonas*

Superclass (B) Opalinata

1. Body covered by flagella or cilia.

2. Nuclei 2 to many and monomorphic.
3. Nutrition saprozoic.
4. Reproduction by binary fission or by gametes.
5. Parasites of frogs and toads.

   E.g. *Opalina.*

Superclass (C) Sarcodina (Rhizopoda)

1. Body without definite pellicle.
2. Locomotion by pseudopodia.
3. Nutrition holozoic or saprozoic.
4. Asexual reproduction by binary fission.
5. Solitary and free living some parasitic or colonial.

Class- 1. Actinopodea

Pseudopodia are axopodia with axial filaments radiating from spherical body.

Subclass (1) Heliozoa

1. Spherical protozoans.
2. Pseudopodia (axopodia) radiating.
3. Body naked and differentiated into outer vacuolated ectoplasm and inner dense endoplasm.
4. Nutrition holozoic.
5. Mostly freshwater.

   E.g. *Actinophyrus, Clathrulina, Actinosphaerium.*

Subclass (2) Radiolaria

1. Perforated central capsule separating the ectoplasm from endoplasm.
2. Contractile vacuole absent.
3. Pseudopodia are axopodia or filopodia.
4. Skeleton of siliceous spicules.
5. Marine.

   E.g. *Collozoum.*

Subclass (3) Proteomyxidia

1. Pseudopodia are filopodia.
2. Marine or freshwater.

3. Reproduction by binary fission or multiple fission.

   E. g- *Pseudospora.*

Subclass (4) Actantharia

1. Central capsule non chitinoid and without pores.
2. Skeleton of strontium sulphate.
3. Pseudopodia are axopodia.

   Eg- *Acanthrometra*.

Class 2. Rhizopodea

Pseudopodia are lobopodia, filopodia or reticulopodia, without axial filaments.

Subclass (1) Lobosia

Pseudopodia are lobopodia.

Order- 1. Amoebida

1. Body amoeboid shaped, without skeleton
2. Pseudopodia (lobopodia) short with blunt ends.
3. Ectoplasm and endoplasm distinct.
4. Largely fresh water, some parasites.

   E.g. *Amoeba, Entamoeba*.

Order- 2. Arcellinida (Testacida)

1. Body enclosed in one chambered shell.
2. Shell with a single opening through which lobopodia protrude.
3. Free living, found in fresh water.

   E.g. - *Arcella, Difflugia*.

Subclass (2) Filosia

1. Pseudopodia are filopodia, tapering and branching.
2. Body naked or with a shell wit single aperture.
3. Ectoplasm not distinct.
4. Marine and freshwater forms.

   Eg- *Allogromia, Penardia*.

Subclass (3) Granuloreticulosia

Pseudopodia are reticulopodia.

Order-1. Foraminiferida

1. Large sized with uni or multichambered shell.
2. Shell with one or more opening through which reticulopodia emerge.
3. Reticulopodia fine and branching is forming a network.
4. Mainly marine,

   E.g. *Globigerina*,

Subclass (4) Mycetozoia

1. Body large, amoeboid and multinucleate.
2. Pseudopodia numerous and blunt.
3. From sporangia with spores.

   E.g. *Slime moulds.*

Class-3. Piroplasmea

1. Small parasite in R.B.Cs. of vertebrate.
2. Do not form spores.

   E.g. - *Babesia.*

Subphylum II. Sporozoa

1. Exclusively endoparasites.
2. Body with thick pellicle.
3. Locomotor organelles absent in adult.
4. Nutrition saprozoic.
5. Asexual reproduction by multiple fission and sexual reproduction by syngamy followed by spore formation.
6. Life cycle includes both asexual and sexual phase.

Class1. Telosporea

1. Spores without polar capsules or filaments.
2. Sporozoites elongated, microgamete flagellated.
3. Trophozoties with one nucleus only.

Subclass -1. Gregarinia

1. Trophozoites large and found in the gut and body cavities (i.e. extracellular) of invertebrates.
2. Zygote non motile.

3. Male and female gametes merogamous.
4. Sporozoites found in sporocyst.
5. Parasites of invertebrates.

   Eg. *Monocystis*, *Gregarine*.

Subclass- 2. Coccidia

1. Trophozoites small and intracellular.
2. Gametophytes dimorphic.
3. Sporozoites in sporocysts.
4. Blood or gut parasites of vertebrates.

   Eg- *Eimeria*, *Isospora.*

Class 2. Toxoplasmea

1. Spores not formed.
2. Only asexual reproduction.

   E. g- *Toxoplasma.*

Class 3. Haplosporea

1. Spores with spore cases.
2. Parasitic of fish and invertebrates.
3. Pseudopodia may be present but no flagella.
4. Reproduction by schizogony only (asexual)

   E.g. *Ichthyosporidium*, *Haplosporidium*

Subphylum- III. Cnidospora

1. Trophozoite has many nuclei.
2. Spore formation occurs throughout life.
3. Spores contain polar capsules with polar filaments.

Class 1. Myxosporidea

1. Spores develop from several nuclei.
2. Spore within two or three valves.

Order -1. *Myxosporida.*

1. Spores large and with a bivalve membrane.
2. Polar capsule 1, 2 or 4; each with a filament.
3. Tropozoites amoeboid.

Eg. *Myxidium.*

Order- 2. Actinomyxida

1. Spores large and with a trivalved membrane.
2. Polar capsule 3, each with a filament

   Eg. *Triactinomyxon, Sphaeractinomyxon.*

Class-2. Microsporidea

1. Spores small and with a univalved membrane.
2. With or without polar capsule

   E.g. *Nosema*.

Subphylum – IV. Ciliophora

1. Body organization complex.
2. Presence of cilia as feeding and locomotory organelles at some stage in the life cycle.
3. Two types of nuclei- micronucleus and macronucleus are present.
4. Asexual reproduction by binary fission or budding.
5. Sexual reproduction by conjugation.

Class1. Ciliate (Infusoria)

1. Protozoa with a definite from and size.
2. Body bounded externally by a firm pellicle.
3. Locomotor organelles cilia.
4. Definite mouth and gullet present. Anal Aperture. Permanent.
5. One or more contractile vacuoles present.
6. Have two kinds of nuclei large macronucleus and smaller micronucleus.

Subclass (1). Holotricha.

1. Body cilia uniform.
2. Buccal cilia absent.

Order- 1. Gymnostomatida

1. Body large.
2. Buccal cilia absent.
3. Cytostome opens to outside.

   E.g. *Coleps, Didinium, Nassula*

Order-2. Trichotomatida

1. Cytostome at the bottom of vestibule.
2. Spiral ows of cilia in vestibule; no cilia in bucal region.

   Example; *Colpoda*, *Balantidium.*

Order- 3. Chonotrichida

1. Body vase shaped.
2. Body cilia absent.
3. Funnel at the free end of body with vestibular cilia.
4. Ectocommensal on crustaceans.

   Example- *Lobochona, Spirochona*.

Order- 4. Apostomatida

1. Body with spirally arranged cilia.
2. Cytostome mid ventral.
3. Parasites or commensalism with complex life cycle, completed on two hosts.

   E.g. - *Hyalophysa, Polyspira*.

Order-5. Astomatida

1. Cytostome absent.
2. Body ciliation uniform.
3. Parasites or commensals in gut and coelom of earthworm.

   E.g. - *Anoplophrya, Hoplitophyrya.*

Order-6. Hymenostomatida;

1. Body small and with uniform cilia on body.
2. Buccal cavity with undulating membrane and adoral zone of membrane cells.

   E.g. - *Colpidium, Paramecium.*

Subclass (2) Peritrichia

1. Adult without body cilia.
2. Sessile organism.

Order- 1. Peritrichida

1. Characters of subclass peritricha,

   E.g. - *Vorticella, Carchesium.*

Subclass (3) Suctoria

1. Body sessile and stalked.
2. Young with cilia, adult; with tentacles.

Order 1 Suctorida

1. Characters as of subclass suctorida.

   E.g. - *Ephelota, Podophrya.*

Subclass (4) Spirotricha

1. Body cilia reduced.
2. Buccal cilia well marked.

Order-1. Heterotrichida

1. Body encased in lorica.
2. Body cilia usually absent.
3. Body naked with uniform body cilia.

   Eg. -*Bursaria, Stentor, Blepharisma*.

Order-2. Hypotrichida

1. Body dorso-ventrally flattend.
2. Body cilia at vental side, forming cirri.

   Eg. -*Euplotes, Kerona*.

Order -3. Oligotrichida

1. Body cilia reduced or absent.
2. Buccal membranelles at front end only. E.g. -*Strombidium, Halteria.*

1.4 Study of Paramecium with particular reference

Systematic position

PHYLUM **PROTOZOA**

SUB PHYLUM **CILLOPHORA**

CLASS **CILIATA**

SUBCLASS **HOIOTRICHIA**

ORDER **HYMENOSTOMATIDA**

SUBORDER **PENICULINA**

GENUS ***PARAMECIUM***

Species ***caudatum***

- Paramecium (Gr., Paramekos- oblong + Caudata-tail) is an elongated and slipper shaped animal.
- Paramecium is a typical ciliate microscopic organism.
- Its ten species are recognized all over the world.
- Ciliates are characterized by the presence of cilia as locomotors organelles (Fig.7).

1.4.1-Locomotion in Paramecium

Paramecium shows following two methods of locomotion.

1 -Ciliary movement:

- Cilia are main locomotory organ in paramecium this are fine hair like protoplasmic processes all over the body.
- These are inclined backward and their beating drives the body forward but they may be directed forward and then their strokes push the body backward.
- The cilia of longitudinal row beat one after the other in a metachronial succession or in a metachronous rhythm.

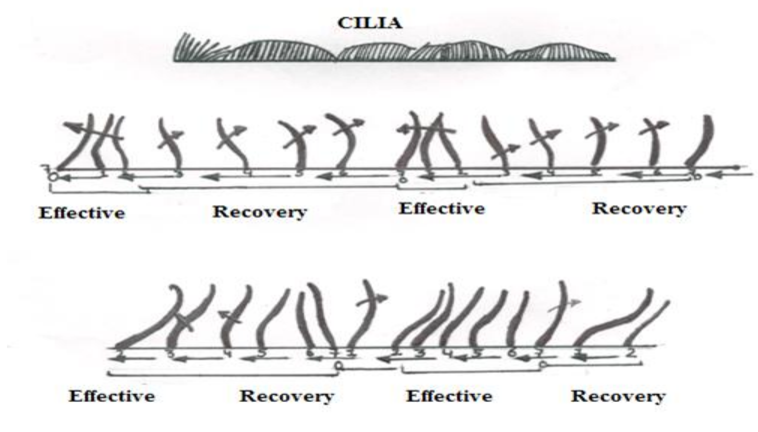

Fig 1.8 Two stages in ciliarry movement (a) Effective (b) Recovery

- The cilia of transverse row vibrate simultaneously.
- The movement of cilia is controlled by the neuromotor system.
- Each oscillation of cilia consists of two stocks, one is effective stock and another is recovery stock.

- The cilia beat somewhat towards the right sight. as a result the body of paramecium rotates spirally slightly toward s the left.
- The cilia of oral groove strike more vigorously and obliquely (Fig.8 and 9).

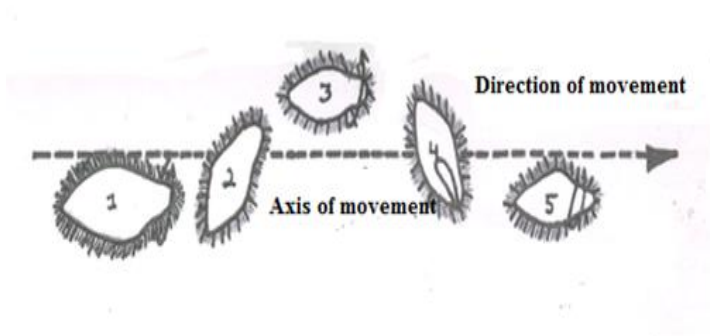

Fig.1.9 Path followed by Paramecium during swimming

2-Body contortions:

Paramecium can pass through a passage narrow than its body by the contraction and twisting of body, after which body assumes its normal size.

1.4.2- Osmoregulation in paramecium:

The amount of water in the body is controlled by the two contractile vacuoles present one on either end of the body.

- Excess of water from cytoplasm is collected in the microtubules of endoplasmic reticulum.
- From here water is passed on to the nephridia tubes and then to feeder canal.
- On getting filled the ampullae discharged it in the contractile vacuole.
- The vacuoles enlarge by gradually receiving water.

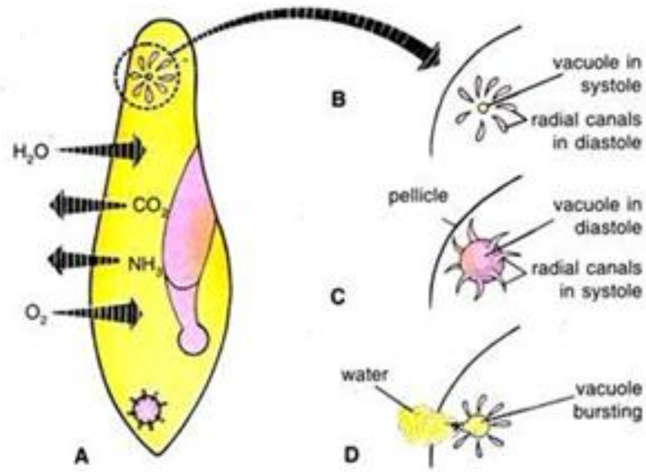

Fig 1.10 Diagramatic representation respiration, excretion & osmoregulation

- When grown to its maximum size, vacuole contracts and empties its water to the exterior through the canal that connects it with a pore in the pellicle.
- When the vacuole is in a state of diastole that is fully distended the feeding canals disappear as small streaks soon after the systole.
- The contractile vacuoles expand and contract at regular interval assisted by the myofibrils.
- The posterior contractile vacuole pulsates much faster than the anterior contractile vacuole probably because of large amount of water reaching the posterior region of the cytopharynx (Fig.1.10).

1.4.3-Nutrition:

Paramecium feeds in the holozoic manner like Amoeba. The food is mostly bacteria found in floating water. It has been estimated that about 2 to 5 million bacteria (Bacillus coli) are devoured in 25 hours by a single Paramecium *P. Bursaria* can live holophytically for long periods due to the presence of symbiotic zoo chlorella algae.

Food is ingested by cytostone situated at the bottom of buccal cavity. Constant lashing movements of cilia direct the food particles towards buccal cavity. Only selected food particle are passed on inside the buccal cavity. Beating of cilica of buccal cavity derives food in to cytopharynx through cytostaome. The food is collected at the bottom of cytopharynx, in the form of a food vacuole. Another food vacuole may be formed within 2 to 4 minutes.

Digestion: Each food vacuole consists of particles surrounded by a thin film of water. Food vacuole in circulated around the body along a definite path by a streaming movement of endoplasm known as cyclosis. Food vacuoles move particularly, than forward and aborally and again posterior & orally up to cytopyge.

Egestion: The vacuole gradually becomes smaller as absorption of digested food proceeds. The undigested residual matter is eliminated through cytopyge or anal spot.

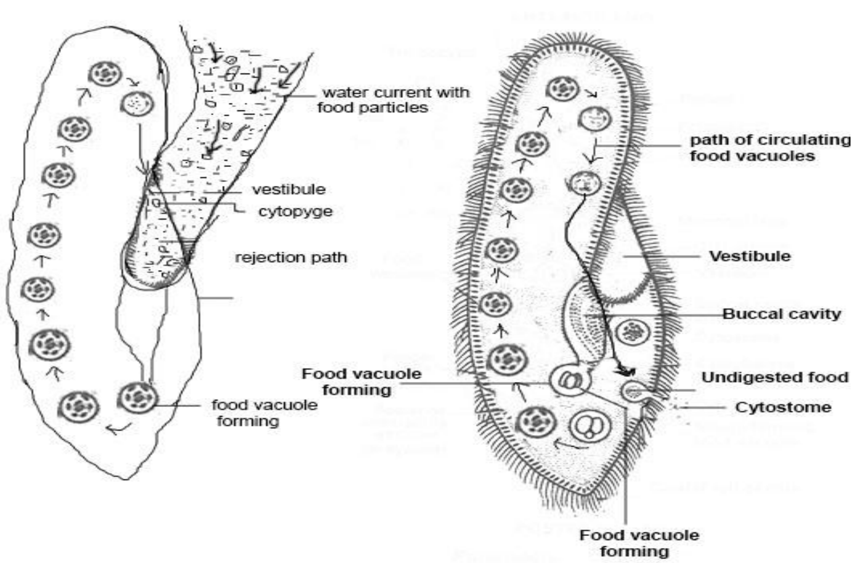

Fig.1.11 Paramecium showing cyclosis and path of food vacuoles in endoplasm

1.4.4- Reproduction in Paramecium

Paramecium multiplies very quickly by transverse binary fission. But this is interrupted at intervals by the so called sexual process conjugation. Several types of nuclear reorganizations such as endomixis, hemimixis, auto gamy and cytogamy have also been reported.

1. Binary fission:

- During favorable conditions paramecium multiplies by transverse binary fission.
- The animal stops feeding and the micronucleus divide into two by an elongated type of mitosis.
- The two daughter micronuclei move apart toward the opposite end.
- Mean while the macronucleus elongates and gets constricted into two amitiotically.

- ❖ A transverse constriction appears in the middle of body, which deepens gradually dividing it into two equal valves.
- ❖ The oral groove of the parent is retained by one half and the mouth and cytopharynx by other. These later on regenerated the essential parts.
- ❖ The contractile vacuole in each half also divides.
- ❖ These now separated and start their free existence.
- ❖ The entire process is completed within half to two hour (Fig.1.12).

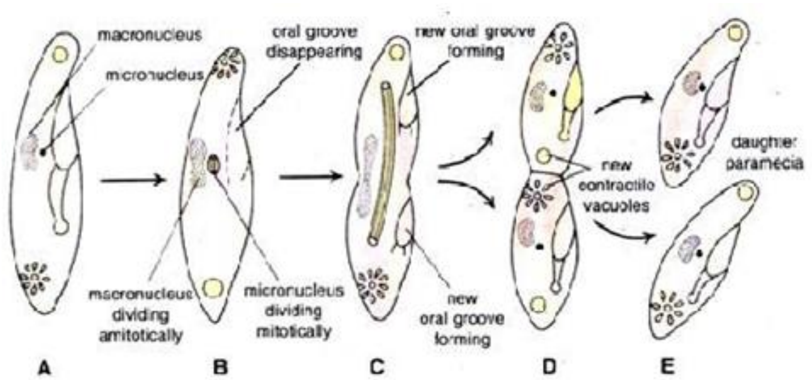

Fig.1.12Paramecium: Stage showing Binnary fission

2-Conjugation:

Conjugation is a temporary process and completed in following steps-

Macronucleus Changes-Soon after pairing the macronucleus degenerates into fragment and is absorbed in the cytoplasm micronucleus Changes:-

A. Simultaneously the micronucleus undergoes two pre-gametic divisions, of which first is reduction division.
B. As a result four daughter micronuclei are formed each with haploid number of chromosome.
C. Three of the four daughter micronuclei degenerate in each conjugant.
D. The remaining micronucleus divides unequally producing a small active migratory male pronucleus and large and passive stationary pronucleus potentially female.

E. The migratory male pronucleus of the two conjugant's are exchanged so that the male pronucleus of one passes into the other and fuses with the female pronucleus forming the zygote nucleus or synkaryon.

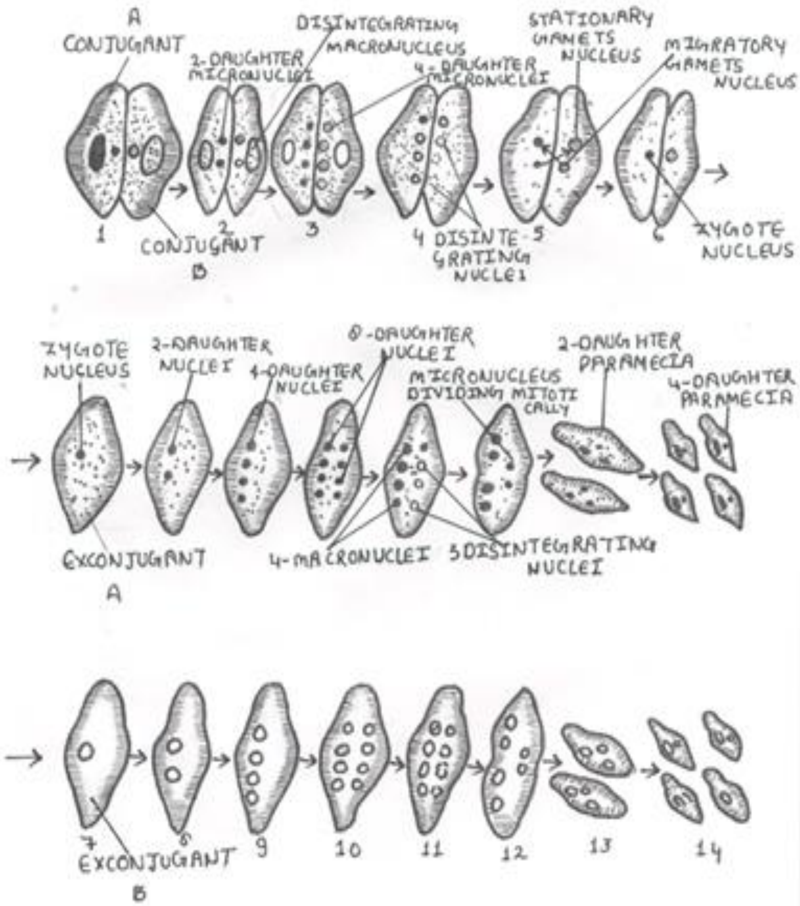

Fig.1.13Paramecium: Stages in Conjugation

F. The conjugant's now separate and is called exoconjugants.

G. The synkaryon in each conjugant divides thrice and eight nuclei are formed.

H. Four of them enlarge and from macronuclei, while the remaining four are known as micronuclei.

I. Three of the four micronuclei disintegrate.

J. The single micronucleus in each exoconjugants divide twice and each division is accompanied with the division of body.

K. As a result four daughter paramecia are formed from each exoconjugants each with one micro and one macronucleus (Fig.1.13).

Significance of Conjugation:-

1-Rejuvenation- It has been found that individuals cannot continue to multiply indefinitely by asexual methods. After a definite number of asexual generations the rate of fission declines.

2. Nuclear reorganization: Old and decaying macronucleus is replaced by a new one during conjugation.

3. Heredity variations: The fusion of pronuclear facilitates exchanges of nuclear material.

Autogamy:-

It is found in *P.aurelia.* The process is similar to conjugation but found in a single individual. This is also called as self-conjugation. In P. Aurelia 2 micronuclei are meiosis to form 8 haploid daughter nuclei. 7 of them disintegrate nuclei. The macronucleus is absorbed in the cytoplasm. The 2-ganetic nuclei fuse to form homozygous diploid zygote nucleus or synkaryors. The zygote nucleus divides twice to form 4 nuclei 2 of which become macronuclei & 2 micronuclei. The call body & the micro nuclei divide to form 2 daughter individuals, each paramecium with a macronucleus & 2 micronuclei. Auto gamy was described by W.F. Diller (1936) in *P. Aurelia*.

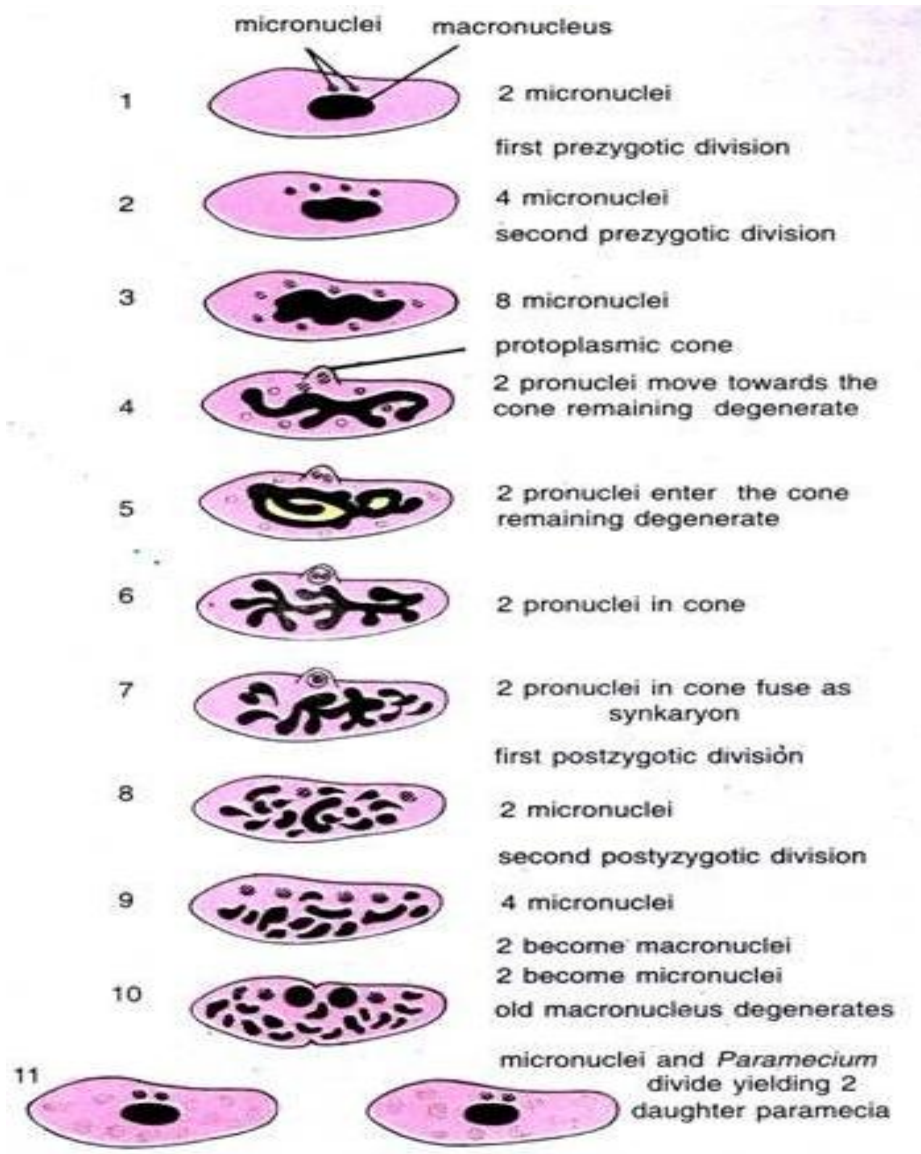

Fig1.14 Diagramatic represeantation of Autogamy

Cytogamy:

It is a sexual process without nuclear exchange thus called as cytogamy. The process resembles conjugation. Two small individuals temporarily fuse by their oral surfaces. The early nuclear divisions are similar to conjugation, but there is no nuclear exchange between two individuals. But two haploid gamete nuclei in each individual fuse to form a synkaryon as in auto gamy. The process completed in about 12 to 13 hours. Cytogamy was reported by R. Wichterman in *P. Caudatum* (1940).

Endomixis - This is the periodic nuclear reorganization in ciliate protozoans. It is internal nuclear reorganization within a single individual taking place in the absence of conjugation. Erdmann & woodruff in 1914, first of all reported in the bimicronucleate species, *P. Aurelia* at regular intervals of about 30 days. The macronucleus disappears & degenerates. The micronuclei (2) divide twice mitotically forming 8 daughter nuclei of which 6 degenerate. At this stage Paramecium also divides, each daughter has one micronucleus. This micronucleus divides twice forming four micronucleus, two of which become microlei & two macronuclei, in each individual. The micronuclei again divide with the binary fission of Paramecium into two daughters, each getting one macronucleus & two micronuclei. Thus 4 daughters are produced from a single parent.

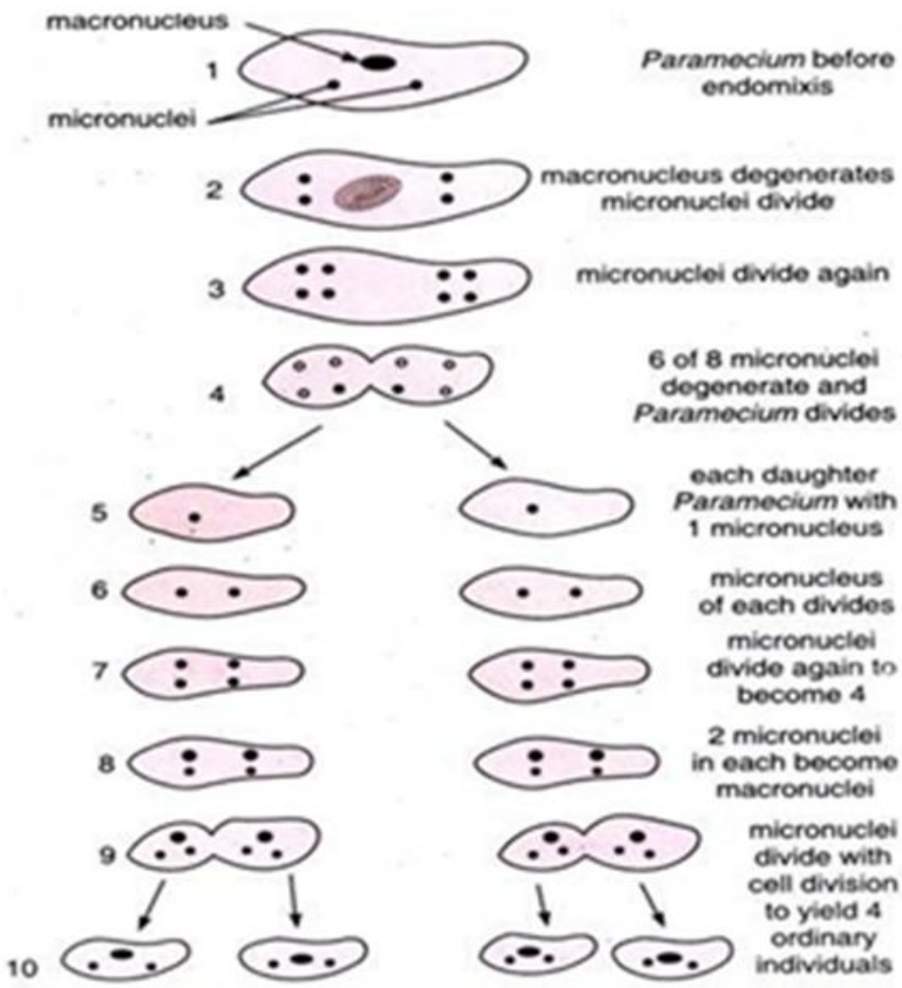

Fig 1.16 Stages of endomixis in Paramecium

1.8-Self assessment question:

1. Describe the structure of Paramecium?

2. Describe the mode of nutrition and locomotion of *Paramecium*?

3. Give an account of the reproductive processes in *Paramecium?*

4. Classify phylum Protozoa upto orders?

5. Which type of excretion is found in protozoa? How does excretion occur in protozoans?

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1.11-Terminal Questions:

1. What are the methods of reproduction in Protozoa?

2. What are the methods of nutrition in protozoa?

3. Describe the process of osmoregulation in *Paramecium*?

4. In some protozoans, a special structure called vacuole is present. What is its function and where is it found in protozoans?

5. Differentiate between commensalism and parasitism?

6. Describe modes of locomotion in protozoa?

1.12-Multiple Choice Questions:

1. Coprozoic nutrition is found in-
(a) Balantidium [ ] (b) Euglena [ ] (c) Noctiluca [ ] (d) Copromonas [√]

2. Holophytic (autotrophic) nutrition-
(a) Paramecium [ ] (b) Balantidium [ ] (c) Euglena [√] (d) Nyctotherus [ ].

3. Saprophytic or saprozoic nutrition is found in-
(a) Euglena [√] (b) Leishmania [ ] (c) Amoeba [ ] (d) Monocystis [ ].

4. Photoreceptor organof euglena is-
(a) Stigma near reservoir [ ] (b) Paraflagella body at the base of flagellum [ ] (c) Stigma and paraflagella body [√] (d) chromatophore [ ].

5. Lactoflavin (sensitizer) found in-
(a) Eye spot [ ] (b) Paraflagella body [√] (c) Golgi bodies [ ] (d) mitochondria [ ]

UNIT 02: PHYLUM- METAZOA

2.1- Objectives

(1) Study of Germ layers.

(2)Study of diploblastic and triploblastic Organization.

2.2-Introduction

Metazoans are the multicellular organism which develops from embryo; they are heterotrophic and motile eukaryotes organisms. Their body is polarized along an anterior-posterior locomotory axis. Metazoans body is composed of functional specialized cells, each type of which is dedicate to one or a few functions.There is a great diversity in metazoans and according to the most widely accepted groupings there are 30 phyla of which only one, viz. the chordata, contains animals which are not invertebrates. The important features on the basis of which the metazoan hierarchy is decided are: symmetry, coelom and metamerism.

Lower and higher Metazoa:

We saw that animal phyla can be arranged in several different ways on the basis of their structural traits, as follows:

1. Asymmetrial (most Porifera), radially symmetrical (Coelentrata) and bilaterally symmetrical (all others).
2. Diploblastic (Porifera and Coelentrata) and triploblastic (all others).
3. Acoelomate (Porifera to Plathelminthes), Pseudocoelomate (Entoprocta, Acanthocephala, Aschminthes) and coeloate (all others).
4. Segmented (Annelid. Arthopoda, Tardigrada, Chordata) and coelomate (all others).
5. Chordates (Proto-chordata and Vertebrate) and non- chordates (all others).
6. Vertebrates (higher chordates) and invertebrates (all others).

Major Groups of Animals	Phyla	Number of species
Subkingdom I Protozoa..............	➢ 1. Protozoa	50,000
Branch 1. Mesozoa...........	+ 2. Mesozoa	50
Branch2. Parazoa............	➢ 3. Porifera	5,000
Grade A. Radiata	➢ 4.Coelenterata	11,000
	+5. Ctenophora	90
(i) Subdivision Acoelomata	➢ 6. Platyhelminthes	15,000
	+7. Rhyncocoela (Nemertinea)	750
(ii)Subdivision Pseudocoelomata	+8. Acanthocephala	500
	+9.Entroprocta	60
	+10. Rotifera	1,500
	+11. Gastrotricha	175
	+12. Kinorhyncha	100
	➢ 13. Nematoda	12,000
	+ 14. Nematomorpha	100
(iii)Subdivision Lophophorate Coelomata	+15. Phoronida 15	
	+16. Ectoprocat (Bryozoa)	4,000
	+17. Brachiopoda	260
(iv) Subdivsion Schizocoelous Coelomata	+18. Priapulida	08
	+19. Spinunculida	275
	➢ 20. Mollusca	80,000
	+21. Echurida	60
	➢ 22. Annelida	8,700
	+23. Tardigrada	180
	+24. Onychophora	73
Subkingdom II. Metazoa	➢ 25. Arthropoda	900,000
Branch3.Eumetazoa **Subdivision Enterocoelous Coelomates**	26. +Pentastomida	70
	27. +Chaetognatha	50
Grade B. Bilateria	➢ Echinodermaa	6,000
Division 2. Deuterostomia	+29. Pogonophora	80
	+30.Hemichordata	80
	*31. Chordata	49,000

- **➢ Shows major phyla discussed in detail in this volume and + Shows Minor Phyla.**

*** Treated in second volume on "Vertebrates".**

1. Lower Metazoa:

- Porifera, Colenterata, Platyhelminthes, Aschelminthes, Entoprocta and Acanthocephala are generally called Lower Metazoa.

- They are unsegmented, radially or bilaterally symmetrical, diploblastic or triphloblastic and acoelomate.

2. **Higher Metazoa:**
    - The remaining phyla namely Mollusca, Annelida, Arthopoda, Echinodermata and Chordata etc. are known as higher Metazoa.
    - They are triploblastic and truly coelomate animals.
    - Except chordata, all are non-chordates or invertebrates.
    - However, the lower and higher metazoan phyla, based on structural traits or characters, must not be confused with the Minor and Major phyla which are based on different criteria, such as the number of species and individuals and their participation in ecological communities

2.3-Germ layers:-

The primitive cell layers, or first tissues, which appear early in the development of animals and from which the embryo body and its auxiliary membranes, when present, are constructed. These are more or less distinct anatomically, but do not necessarily have sharp boundaries of demarcation.

Germ layers are almost universal among animal embryos and appear to establish discontinuities of architectural importance without complete loss of continuity.

Three kinds of germ layers are recognized:

(1) The ectoderm or outer layer

(2) The endoderm or inner layer

(3) The mesoderm or middle layer

The layers have been named in accordance with their positions in the spherical type of gastrula such as that of the sea urchin or amphibian. The terms epiblast, mesoblast, and hypoblast are sometimes used as synonyms for ectoderm, mesoderm, and endoderm, respectively. The majority of organisms have all three primary germ layers: the exterior, or ectoderm; the interior, or endoderm; and the middle, or mesoderm. Exceptions are the sponges and coelenterates, in which only two germ layers are formed, the exterior and the interior and a distinct mesodermal layer are absent.

Derivatives of the ectoderm:

- Perform integumental, sensory, and motor functions:
    - In the course of embryonic development they give rise to the nervous system;
    - The skin integument and the skin glands that are formed from it;
    - The hair, plumage, scales, nails, and so forth;
    - The epithelium of the anterior and posterior sections of the digestive system;
    - The connective-tissue foundation of the skin; the pigment cells; and the visceral skeleton.

Derivatives of the endoderm:

- The endoderm forms the lining of the intestinal cavity
- Provides nutrition for the embryo;
- From it originate the mucous membrane of the digestive system, the digestive glands.
- Forms the organs of respiration.

Derivatives of the Mesoderm:

- The mesoderm effects communication between the parts of the embryo
- Performs supportive and tropic functions;
- From it are formed the organs of excretion, the sex organs,
- Forms the circulatory system, and
- Forms the serous membranes that line the secondary body cavity (coelom) and clothe the internal organs and muscles;
- In vertebrates the skeleton is also formed from the mesoderm.

Analogous germ layers in different groups of organisms may have, in addition to common traits, substantial differences in their manner of formation and their structures, because of the adaptation of the embryos to different conditions of development.

2.4- Metazoan Organization

Animals show various patterns in their morphology. Relationships between animals or groups of animals are best explained by their cooperative morphology and embryology.

The gross external morphology of animals falls under a limited number of patterns (criteria).

- These include form of animals (symmetry),
- arrangement of body parts in segments (metamerism),

- formation of a head (cephalization), and
- Progressive sequence of specialization of structure (levels or grades of organization).

Similary, the criteria of internal morphology are differences in formation of body cavity (coelom) and reproduction (embryology), etc.

Symmetry and its significance:

- Symmetry means an arrangement of body parts into geometrical designs. It refers to the division of body into equal parts by lines or planes.
- An animal is called symmetrical when a plane passing through its centre will divide into similar halves.
- When an animal cannot be divided into like parts by a plane, it is called asymmetrical e.g. sponge, some Protozoa (Amoeba) and few others.
- Certain terms are often used when explaining symmetry.
- **An axis** is an imaginary line passing through the center of body, such as longitudinal axis and oral-aboral axis. Either end of an axis is termed a pole. Thus, each axis has two poles.
- **A plane of symmetry** is a straight line that divides into corresponding halves.
- Metazoa commonly display two types of symmetry, radial and bilateral. Two other types of symmetry are also recognized, spherical and biradial.
- Protozoa are not only asymmetrical but display all four types of symmetry in their diverse body forms.

1. Spherical symmetry:

- It is found in animals whose body has the shape of a sphere.
- All planes that pass through the center will cut it into similar halves.
- Some protozoans (e.g.Volvox, Helozoa, Radiolaria) have sepherical symmetry, and it is adapted for free-floting or rolling movments (Fig.2.1).

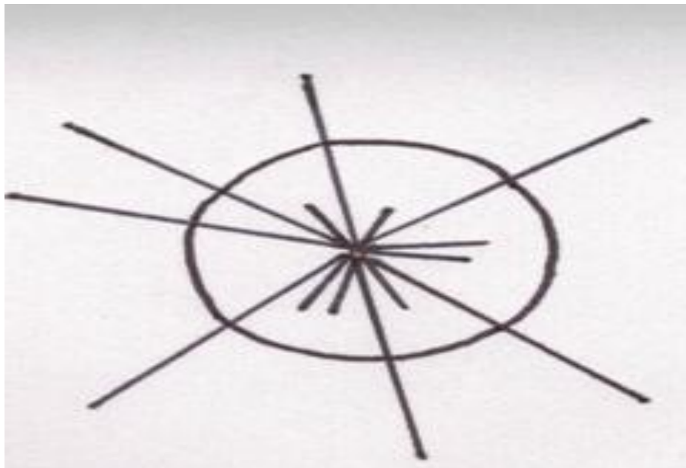


Fig 2.1Spherical Symmetry

2. Radial symmetry:

- Many similar body parts, called antimeres, are arranged around one main, central or longitudinal axis in a circular or radiating manner like the spokes of a wheel.
- All the lines passing through this longitudinal axis, in any plane, will divide the body into equal halves or antimeres.
- The surface having mouth is the oral surface, and the opposite surface is the aboral surface. Examples are echinoderms and most colelentrates (e.g. Hydra).
- The body is in the form of a flat or tall cylinder.
- Radial symmetry is best suited for a sessile existence.
- Most of them attached by the aboral surface.
- Some are free-swimming but remain at the mercy of water current.
- Due to similarity of antimeres, their sensory receptors are equally distributed all around the periphery.
- This enables them to receive stimuli and to meet the challenges of the environment equally from all direction.
- They can obtain food or repel enemies from all sides (Fig.2.1).

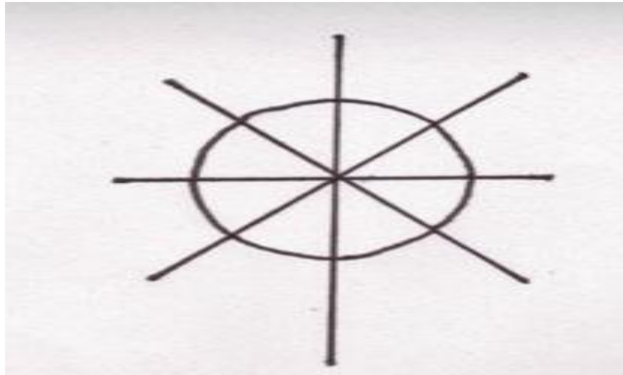


Fig 2.1 Radial Symmetry

In the animal kingdom, radially symmetrical phyla and porifera, Coelenterata, Ctenophora and Echinodermata. Out of these, only Coelenterata and ctenophore display a fundamental radial symmetry. Both the phyla were groupe together by Haatschek (1888-91) under the division Radita. Adult porifera are mostly asymmetrical larva. On the other hand, larval stage of Echinodermata has bilateral symmetry, but the adults become radilly or pentaradially symmetrical.

3. Biradial symmetry:

- It is a variant from of radial symmetry found in Ctenophora and most Arthozoa (e.g.anemones), and is best fitted for a floating life.
- There are only 2 planes of symmetry, one through the longitudinal and sagittal axis and the other through the longitudinal and transverse axis, which will divide the animal into equal halves (Fig.2.3).

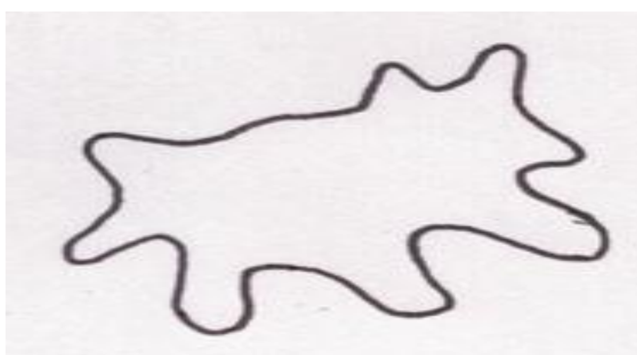


Fig 2.3 Asymmetry

4. Bilateral symmetry:

- In higher animals, the longitudinal axis of body runs from the anterior end (head) to the posterior end (tail).
- There is a single plane, the median longitudinal or sagittal plane, through which the body can be divided into two similar rights and left halves. This is called bilateral symmetry.
- Besides right and left sides, an upper or dorsal surface and a lower or ventral surface are also recognizable, which are unlike because they are exposed to different condition.
- Bilateral symmetry is characteristic of the most successful and higher animals, including the remaining invertebrates and all vertebrates. In most of them, the anterior end is differentiated into a head (Fig.2.4).

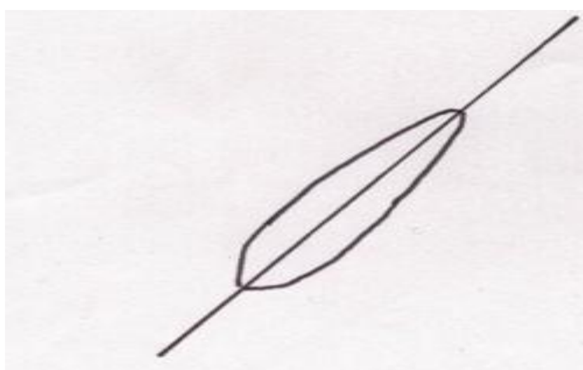


Fig 2.5 Bilateral Symmetry

- First phylum of animal kingdom to exhibit bilateral symmetry is the phylum Platyhelminthes.
- All bilateral symmetrical metazoans were grouped together by Hatschek (1988-91) under the division bilateria. As already mentioned earlier, some bilateria, such as echinoderms, display a radial symmetry which has been secondarily derived from bilateral ancestors due to assumption of an attached mode of life by adults.
- Cephalization and Polarity; Bilateral symmetry is correlated with the locomoter movements brought about by these animal. One end of their body, usually containing the mouth, always moves forward in a particular direction.

- It is the first to come in contact with the environment, so that there is great concentration of nervous tissue and sense organs at this anterior end called head. The posterior or rear end is usually equipped with some locomotory organ. This modification of anterior or oral end of the animal into a definite head is called cephalization which is characteristic of most bilateral animals.
- Cephalization is always accompanies by a differentiation along an antero-posterior or oral aboral axis. This condition is known as polarity, and it usually involves gradients hitch refers to ascending or descending activates between anterior and posterior ends.

2.4.1-Diploblastic and Triploblastic Organization

- In Metazoa, special regions of the body are set aside for dealing with different functions.
- The Metazoa produce gametes of two types, the male gametes are spermatozoa and female gametes are ova.
- A spermatozoon fertilizes an ovum to from a zygote which undergoes a series of mitotic cell division to from a hollow ball of cells called blastula it has a cavity known as blastocoel.
- Further increase of the cells of the blastula causes an invagination of the wall on one side, and by different processes the cells eventually come to lie in two layers, an outer layer of ectoderm and an inner layer of endoderm, the blastocoel is obliterated; the mouth of the invagination is a blastopore which leads into a new cavity, the archenteron; this two layered bag is a gastrula.
- The development of some Metazoa stops at gastrula stage, these two –layered Metazoa are diploblastic, such as Cnidaria and Ctenophora.
- In all other metazoan phyla, a third layer of cells called mesoderm arises between the ectoderm and endoderm.
- The phyla which possess three layers are triploblastic, and their mesoderm opens up further possibilities of increase in size and complexity.
- In triploblastic phyla, the ectoderm and endoderm retain most of the function which they perform in diploblastic animals.

- The ectoderm forms the outer protective epidermis, external sense organs, nephridia and the nervous system, but in Echinodermata, part of the nervous system is mesodermal in origin.
- The endoderm gives rise to the lining of alimentary canal and organs associated with digestion and respiration.
- The mesoderm is not single entity but has parts which originate in two ways; the cells which migrate from the ectoderm or endoderm form a loose cellular tissue called mesenchyme which fills the spaces between the other layers, and it is comparable to the cells which are found in the mesogloea of Cnidaria.
- The second type of cells which from the wall of the body cavity are known as mesothelium or real mesoderm which gives rise to connective tissue, muscles, skeleton, blood, circulatory system, excretory system and reproductive system.
- In lower triploblastic phyla (Platyhelminthes and Aschelminthes), there is no mesothelium, in Chaetognatha there is no mesenchyme, but the other phyla possess both kinds of mesoderm.
- The triploblastic acoelomate animals may attain a degree of complexity not seen in diploblastic animals. (Fig.2.5).

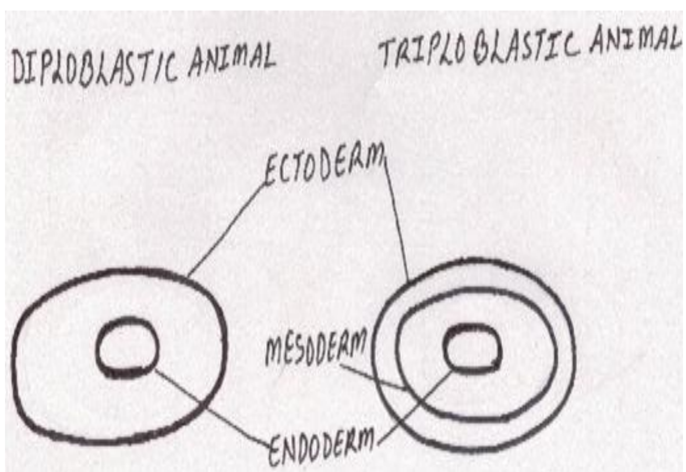


Fig 5. Diploblastic & Triploblastic Animal

Eg. Diploblasts (e.g. *Hydra, Nematostella-)* - Only two germ layers Radial Symmetry.

Triploblasts or Bilateria (the rest) **-** Three germ layers Bilateral Symmetry

2.4.2- Theories on the origin of metazoans:

Cnidarians have been regarded as the most primitive eumetazoan and the possession of radial symmetry has been regarded as a primitive character of cnidarians. The origin of metazoa is based on this assumption.

(1) COLONIAL THEORY:

Most widely accepted theory was first conceived by Haeckel (1874). Later, the theory was modified by Metschnikoff (1887) and Hyman (1940). According to this theory the ancestors of the metazoans are the flagellates. The ancestral metazoan probably arose from a spherical, hollow, colonial flagellate. The colony possessed a distinct anterior-posterior axis with monoflagellate cells on the outer surface. It moved with its anterior axis forward. The somatic cells were differentiated from the reproductive ones. This hypothetical stage was called **blastaea**. It is believed to reflect, the blastula stage which occurs in the development of all animals. The blastaea invaginated to produce a double-walled **gastrea** which was regarded as the hypothetical metazoan ancestor by Haeckel. This gastrea was equivalent to the gastrula stage in the embryonic development of living metazoans. Division of labor of the somatic cells probably led to increasing interdependence of cells and finally an original colony of unicellular individuals became a multicellular organism.

Metschnikoff argued that the originally hollow blastaea became transformed into an organism having a solid structure (gastraea) by the proliferation of the cells from the blastula wall into the blastocoel. This hypothetical ancestral metazoan is believed to be radially symmetrical, ovoid, with no definite mouth. The outer flagellated cells assumed a locomotory function while the inner ones were nutritive and reproductive in function.

This hypothetical ancestral metazoan resembled the planula larva of cnidarians and has been called as the planuloid ancestor who has given rise to the lower metazoans **.**Thus, this theory clearly suggests that the cnidarians have been derived from the planuloid ancestor and that the radial symmetry is primary one and that the bilateral symmetry is a later modification.

(2) CELLULARISATION / SYNCYTIAL THEORY:

Hadzi (1953) and Hanson (1977) are the chief proponents of this theory. They suggested that the metazoans have evolved by the cellularization of a syncytial protistan. According to them most primitive acoelous turbellarians e.g. *Convoluta* were derived from multinucleate ciliated protistans by the process of cellularisation. Since many ciliates tend towards bilateral symmetry they argued that the ancestral metazoans were bilaterally symmetrical and gave rise to the acoels which were regarded as the primitive living metazoans.

POINTS IN FAVOUR:

(a) Size of the acoels is comparable to the ciliates.

(b) Acoels are also ciliated.

(c).Bilaterally symmetrical.

(d).Both lack a hollow digestive cavity.

(e).Imperfect cellularisation is found in the acoels. Syncytial aggregates have been found in the central region of the parenchyma of the acoels.

However, Hadzis theory also suggests that the Cnidarians, more specifically the anthozoans were derived from the turbellarians and that their radial symmetry is because of their sessile mode of existence. These cnidarians retained some of their ancestral bilateral symmetry internally in the stomodaeum, mesentries and muscle bands. Thus, according to this view, the Hydrozoans are advanced rather than being primitive and that their simple structure is a secondary adaptation to its mode of existence.

CRITICISM:

- This theory is based on the adult structure and disregards the embryological evidences.
- The development of turbellarians, nemerteans, annelids, molluscs and some other groups show spiral cleavage which is not found in cnidarians or ctenophora.
- The cnidarians show a wide variety of cleavage patterns suggesting a primitive nature of this group.
- The mere fact that cnidarians have evolved from the turbellarians would mean the abandonment of spiral cleavage which seems improbable.

- The primitive groups are generally more variable with a simple body plan than the highly evolved ones.
- Hydrozoans are more variable than either Anthozoa or Scyphozoa or Turbellaria and therefore Hydrozoa should be considered most primitive. However, according to Hadzi, hydrozoans are regarded as advanced and their structural simplicity is a secondary development.
- According to this theory, the acoels are the most primitive living metazoans. Thus, the bilateral symmetry becomes primitive for the metazoans. This would mean that the radial symmetry of the cnidarians has been secondarily derived from the flatworms. Many zoologists now doubt that the acoels are the most primitive flatworms.
- A ciliate ancestry does not explain the occurrence of flagellated sperm in metazoans.
- Most sessile animals are hermaphrodite. With a few exceptions, anthozoans are not hermaphrodites. Thus, it seems dubious to consider anthozoans as the descendants of hermaphroditic turbellarian

2.7- Self assessment question:

1. What are Metazoa and how do they differ from Metaphyta?

2. Define true metamerism and give the various theories of its origin and evolution in metazoan?

3. What is coelom? Describe its conditions throughout Metazoa?

4. Give an illustrated account of various grades or level of structure met within the animals?

2.8-References

- R.L.Kotpal, R. L. (2003). Morden text book of Zoology Invertebrate.
- E. L. Jorden and P. S. Verma (2015). Invertebrate Zoology

2.9-Terminal Questions

(1).Give a detailed account of Metazoa**?**

(2).Write a note on germ layers?

(3). Difference between diploblastic and triploblastic?

(4). Explain the theories on the origin of metazoans?

UNIT 03: PHYLUM-PORIFERA

(Pours-pore; Ferro-bearing; Robert Grant, 1836)

3.1-Objectives:-

Understanding the general characters and classification up to order level, *Sycon* structure, reproduction and development, different types of canal system and affinities.

3.2-Introduction:-

Members of phylum Porifera or sponges are most primitive of metazoans or multicellular animals. It includes more than 5,000 species. They appear to be quite life-less and plant like. Porifera are a conspicuous and colorful component of many seascapes.

3.3- General characters and classification up to order level

3.3.1- General characters:

1. Porifera is multicellular organisms.

2. All are marine with few exceptions (A single family of freshwater species. e.g., Spongilla).

3. Its shape some time cylindrical, branching, globular, brightly or dull in colour, they are orange, red, yellow or green colour.

4. Solitary or colonial.

5. The body is perforated by pores and canals but lack other organs (mouth or nervous system).

6. Body is asymmetrical or radially symmetrical. Body surface has numerous pores, the ostia, serving for inflow of water.

7. The water current passes through ostia into the chambers and the central cavity and finally comes out of the body through terminal aperture, the osculum.

8. Body wall has outer pinacoderm (dermal epithelium), inner choanoderm (gastral epithelium) and gelatinous non-cellular mesenchyma in between.

9. No definite organ for feeding and digestion.

10. Digestion is intracellular.

11. The water current serves to bring food organisms and oxygen in the body and carry away the excretory and reproductive products.
12. Cells are loosely arranged and do not form definite layers. Thus are not truly diploblastic.
13. Choanocytes (flagellated collar cells) usually line special chambers.
14. Choanocytes are present only in sponges.
15. Sensory and nerve cells absent.
16. Each cell is directly stimulated and transmits sensations to other cells also.
17. Development is indirect through free swimming cilliated larva, the amphiblastula or parenchyma.
18. All sponges are hermaphrodite.
19. The sexual reproduction occurs by the sperms and ova but asexual reproduction by buds or gemmules.
20. Sponges have great power of regeneration.
21. Sponges are cultivated for commercial purposes.
22. About 10,000 species of sponges are known in the world.

3.3.2-Classification up to order level:

The classification of sponge is based chiefly on types of skeleton found in them. This phylum has been classified variously but the classification suggested by Hyman in 1940 and Burton (1967) are of considerable importance. The phylum porifera is divided into three classes:

PHYLUM-PORIFERA

CLASS-1: CALCAREA OR CALCISPONGIAE

- ORDER:
1. Homocoela (Asconosa)
2. Heterocoela (*Sycon*osa)

CLASS-2: HEXACTINELLIDA OR HYALOSPONGIAE

- ORDER:
1. Hexasterophora
2. Amphidiscophora

CLASS-3: DEMOSPONGIAE

- ❖ SUBCLASS- 1 TETRACTINELLIDA
- ➢ ORDER:

1. Myxospongida
2. arnosa or Microsclerophora
3. horistidia

- ❖ SUBCLASS-2 MONAXONIDA
- ➢ ORDER:

1. Halichondrina
2. Poecilosclerina
3. Haplosclerina
4. Hadromerina

- ❖ SUBCLASS-3 KERATOSA

CLASS 1: CALCAREA OR CALCISPONGIAE

- These are small sized calcareous sponges (10cm in height).
- Solitary or colonial.
- Body cylindrical or vase like in shape.
- Skeleton formed of calcareous spicules which may be one, three, or four rayed.
- All are marine animals.
- Body organisation may be asconoid, Syconoid or lenconoid type.

➢ ORDER-1 HOMOCOELA

- Asconoid sponges with radially-symmetrical and cylindrical body.
- Body wall thin and unfolded; choanocytes line the spongocoel.
- Often colonial.

Example- *Leucosolenia, Clathrina*

➢ ORDER-2 HETEROCOELA

- Syconoid and leuconoid sponges with thin walled vase shaped body.
- Choanocytes are found in radial canals or inflagellated chambers only.

Example-*Schypha* (Fig.1-*Sycon*), *Grantia*.

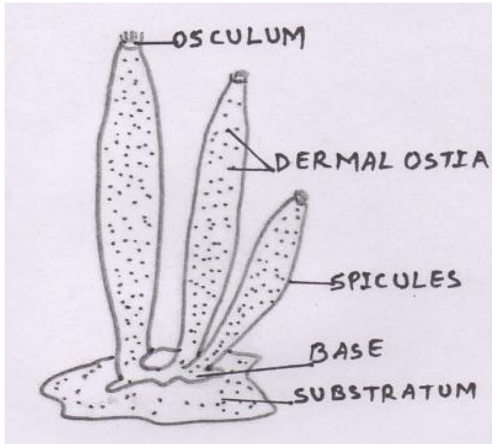


Fig.3.1: Colony of Sycon

CLASS 2: HEXACTINELLIDA OR HYALOSPONGIAE

- Generally hyalospongiae are found in medium sized sponges but some time few sponges reached one meter in length.
- It is commonly known as glass sponges.
- Its body shape cylindrical, funnel shaped or cup shaped.
- The canal system was very typical and body organization Syconoid type.
- Hexactinellida class is found in deep marine water.
    - ➢ ORDER-1 HEXASTEROPHORA
- Spicules are star shaped (six-shaped) eg., hexasters.
- Flagellated chambers regularly and radially arranged.
- Usually attached to substratum directly.

Example-*Euplectella* (Fig.3.2-Venus's flower basket)

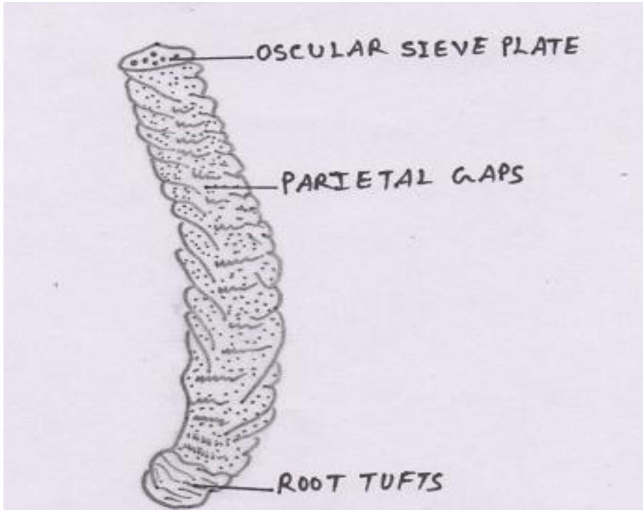


Fig.3.2: Euplectella

- ORDER-2 AMPHIDISCOPHORA

- Spicules with amphidics, i.e. with a convex disc bearing backwardly directed marginal teeth at both the ends-hexasters absent.
- Attached to substratum by root tufts.

Example-(a) *Hyalonema* (Glass-rope sponge),

(b) *Pheronema* (Bowl sponge).

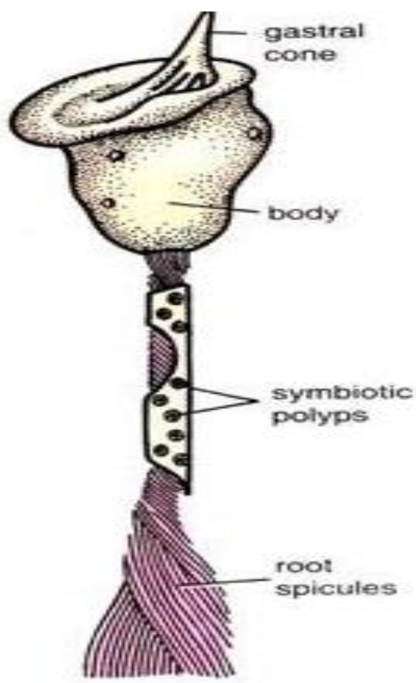


Fig.3.3: Hyalonema

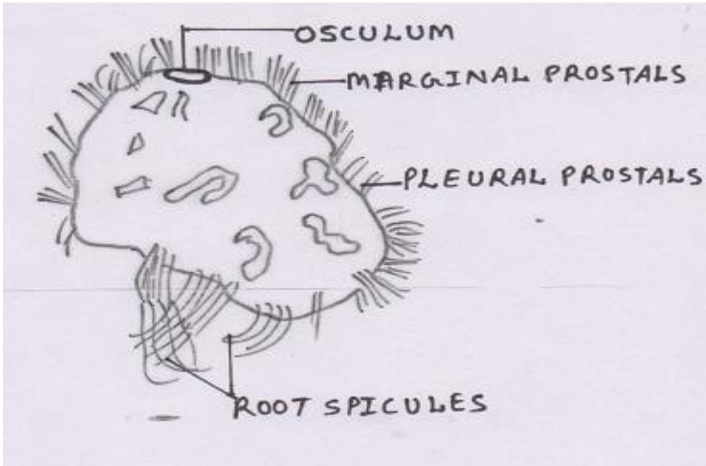


Fig.3.4: Pheronema

CLASS-3: DEMOSPONGIAE

- Solitary or colonial.
- Its body is cup or vase shaped.
- Demospongiae showed both small and large size.
- Spicules are seen monaxon or tetraxon.
- The canal system is leuconoid type.
- All are marine porifera but except freshwater sponges (Spongillidae).
- The class Demospongiae is classified into the three sub classes.

SUBCLASS: 1 TETRACTINELLIDA

- Spicules siliceous and four rayed (tetraxon) or absent.
- Spongin fibres are absent.
- Mostly found in shallow water.
- Subclass Tetractinellida has been divided into three orders-
    - ORDER1- MYXOSPONGIDA
- Both spicules and spongin fibres are absent.
- Structure simple.

  Example- *Oscarella* (Fig.5), *Halisarca*

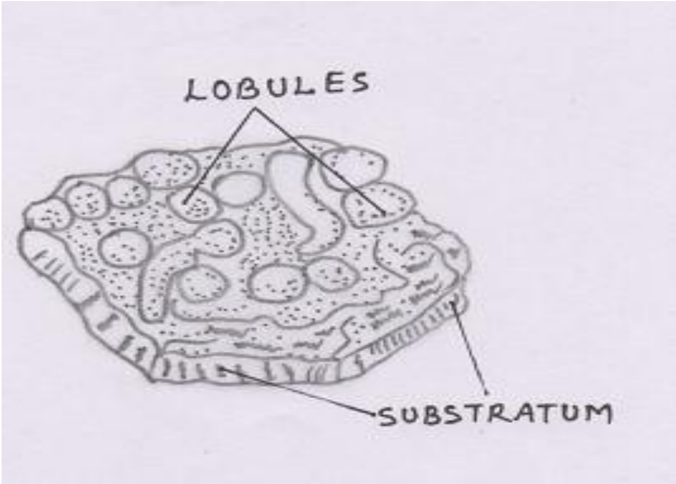


Fig.3.5: Oscarella

- ORDER2- CARNOSA

- Micro and are indistinct.
- All spicules are monaxons.

Example- *Chondrilla* and *Plankia.*

- ORDER3- CHORISTIDA

- Micro. Tetraxon spicules with long axis.

Example-*Thenea, Geodia*

SUBCLASS:2 MONAXONIDA

- Spicules monaxon and siliceous type.
- Spongin fibres some time present or absent.
- Mostly monaxonida is occurring in shallow water.
- Some subclass lives in deep sea but some found in fresh water.
- ORDER1- HADROMARINA
- Spongin fibres absent.
- Microscleres star shaped when present.

Example- *Cliona* (Fig.6; Boring sponge that bores in molluscan shell)

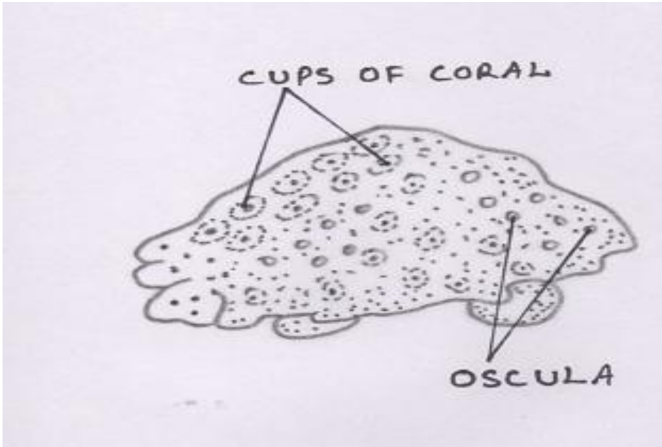


Fig.3.6: Cliona

- ORDER2- HALICHONDRINA

- Spongin fibres very little.
- Microsclers usually absent.

Example-*Halichondria* (Fig.3.7-Crum of bread loaf).

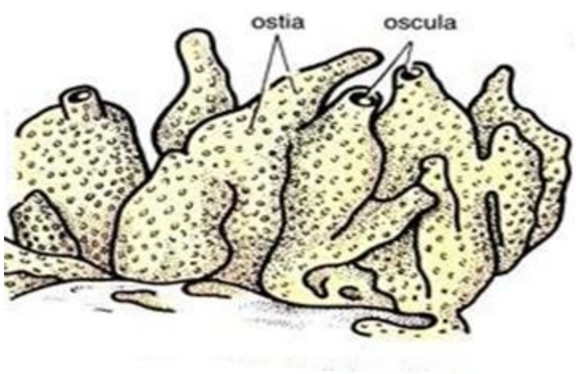


Fig.3.7: Halichondria

- ORDER3- POECILOSCLERINA

- Large spicules or megascleres of many types and united with spongin fibres and form network.
- Microscleres C-shaped.

Example- *Microciona*

- ORDER4-HAPLOSCLERINA

- Megascleres are only of one type having 2-rays only.

- Microscleres may be present or absent.
- Spongin fibres present.

  Example- *Spongilla* and *Chalina*

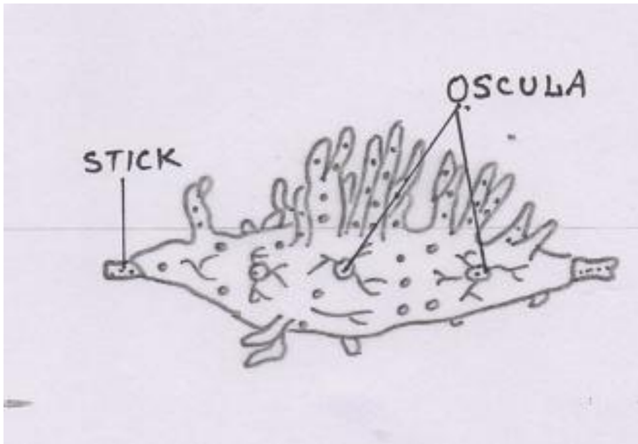


Fig.3.8: Spongilla

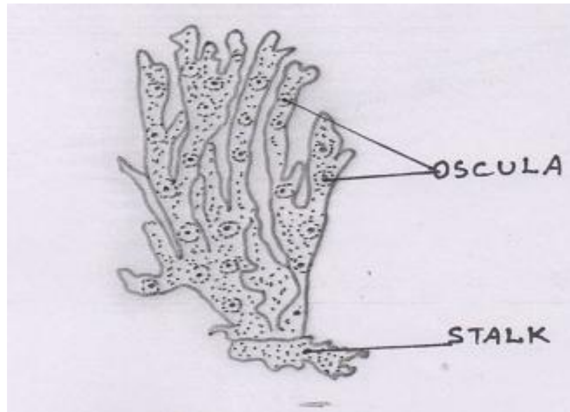
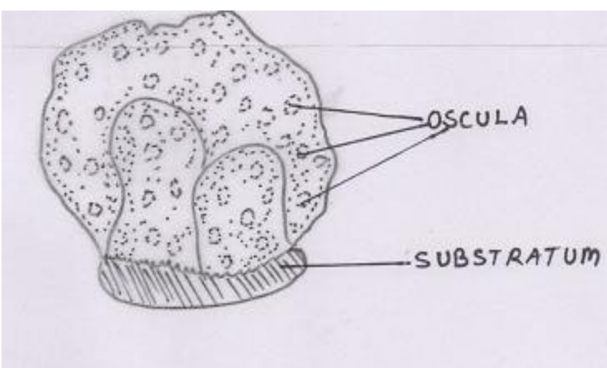


Fig.3.9: Chalina

SUBCLASS: 3 KERATOSA

- Generally spicules are absent in subclass Keratosa.
- The subclass Keratosa consists of horny sponges.
- Skeleton contains spongin fibres only.

  Example- Horse sponge (*Hippospongia*) and Bath sponge (Euspongia).



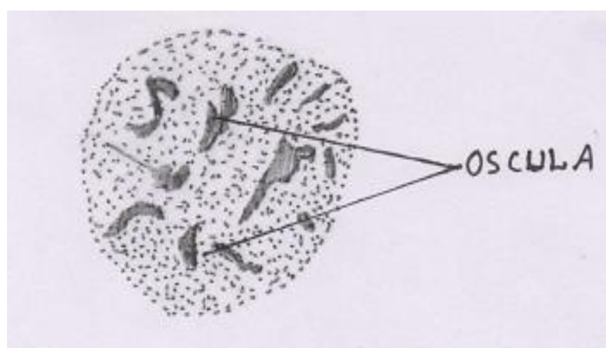


Fig.3.10: Euspongia Fig.3.11: Hippospongia

3.4- Scypha or *Sycon*

Classification:

PHYLUM - PORIFERA
CLASS - CALCAREA
ORDER - HETEROCOELA
GENUS - *SCYPHA*

Habit and Habitat:-

Scyphy or *Sycon* is commonly called as 'urn sponge or crown sponge' because of its typical shape. *Scyphy* or *Sycon* is marine sponge.This has been found widely in nature. It is found attached to submerged rocks in shallow water near coast. It occur solitary or as branching colonial form (Fig.12).Several species of *Scyphy* are *S. elegans, S.ciliatum, S.lingua* and *S. gelatinosum* etc.

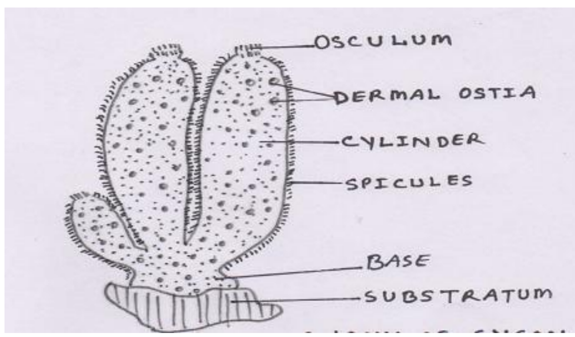


Fig.3.12: Colony of Sycon

3.4.1-Structure:

External morphology:

Shape- The colony has the appearance of a branching tree.It consists of two to several cylindrical branches connected together to a stolon at their bases. The latter is attached to substratum. Each cylinder is vase like.

Size- The size of a cylinder varies from 2-8cms.

Colour- The sponge presents various shades of grey or light brown colour.

Osculum and oscular fringe:

The free distal end of each cylinder has wide opening, the osculum or exhalent pore.

It is surrounded by numerous straight needles like calcareous spicules arranged in a circle.

Dermal pores or *ostia*:

Body surface of *Sycon* has regularly arranged polygonal elevations separated lines or furrows. In furrows present numerous apertures, the ostia or inhalant pores and open into current canals. Entire body surface has spicules protruding out from it.

Canal System in *Sycon:*

Sycon, like all other sponges, possesses the characteristic peculiarity-the canal system. The body wall of sponges is folded to produce complex system of pores and canals for entrance of water current. Scypha or *Sycon* represents *Sycon* type of canal system (Fig.13 and 14).

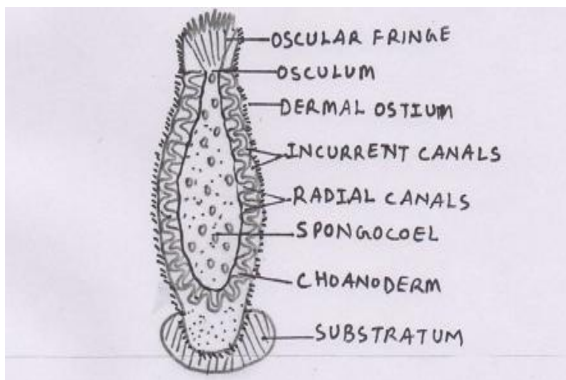


Fig.3.13:L.S of a single cylinder to show internal structure & Canal System

Its components are:

1. Ostia or dermal pores- The external body surface is covered by thin pore membrane.

   It bears two or more openings, the ostia or the dermal pores.

   The pores are surrounded by myocytes.

These can reduce the diameter of dermal pores and thus reduce amount of incoming water. These open into incurrent canals.

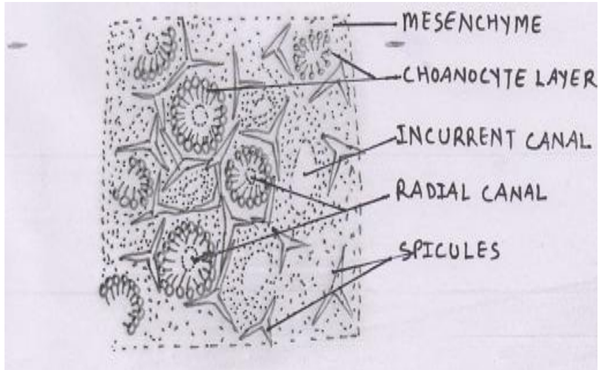


Fig.3.14: V.S of Sycon

2. In current cannels- These are narrow spaces placed radially between adjacent radial canals.These are lined with pinacocytes and opens outside by ostia.
3. Prosopyles- Incurrent canals communicate with radial canals by prosopyles.
4. Radial or flagellated canals- The body of *Sycon* invaginates to form thimble-shaped chambers. Chambers are lined by flagellated choanocytes and called flagellated chambers or radial canals. The radial canals and incurrent canals lie parallel and alternate to each other and are separated by mesenchyme. Radial canals end at their outer ends but open into spongocoel.
5. Apopyles- The openings of radial canals into spongocoel are called apopyles or gastric ostia.
6. Spongocoel- It’s the large central cavity into which radial canals open through apopyles.The choanocytes line radial canals and spongocoel is lined by flattened pinacocytes. Spongocoel is central space all along the length of body.
7. Osculum- The spongocoel opens to outside by a terminal opening, the osculum. Osculum is surrounded is surrounded by a contractile myocytes. These form a sphincter which regulates the rate of water flow.

Mechanism of water circulation:

The water current is produced and water is pumped into the body by beating of flagella of choanocytes which line the radial canals. A wave of spiral undulations passes from base to tip of each flagellum and water is pushed in. Water enters the body by ostia into incurrent canals, from there by prosopyles into radial canals and then by apopyles it reaches spongocoel and discharge into exterior by osculum (Fig.15, 16 and 17).

In other way, the path of water into the canal system can be represented as following-

Water from outside

↓

Dermal ostium

↓

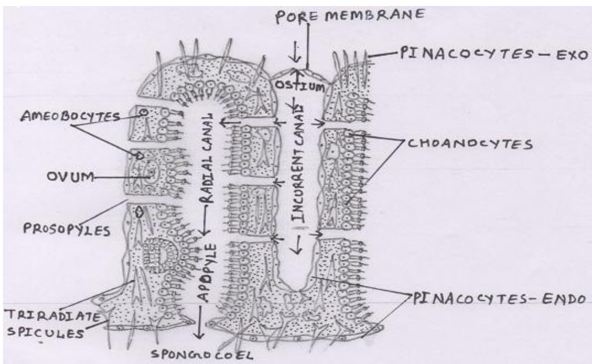
In current canal Exterior

↓ ↑

Prosopyle Osculum

↓ ↑

Radial canal → Apopyle → excurrent canal → Gastric ostium → Paragastric cavity



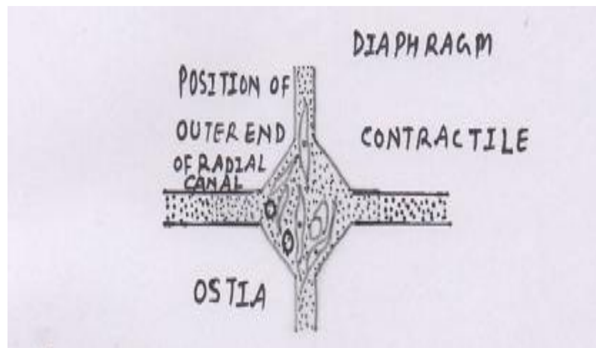


Fig.3.15 *Fig.3.16*

Fig.3.15 Representation of Body wall showing one In-current & one Radial Canal.

Fig.3.16Sycon surface view of pore membrane showing Ostia

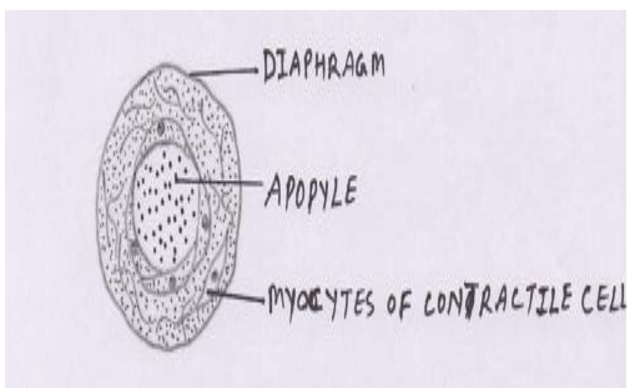


Fig.3.17 Sycon: An apopyle lined by myocyter

Importance of water circulation of canal system:

Water current plays a very important role in the physiology of the sponges. The water circulation system helps the sponges in nutrition, digestion, respiration, excretion and reproduction. The water current brings in food and oxygen and it takes away waste products.

- **Nutrition**

Scypha feeds on particles of organic matter and small living organisms, like a diatoms, bacteria and protozoa; they are drawn in the water current.

- **Digestion**- It is entirely intracellular, as in protozoa.

Partly digested food is taken up by amoebocytes in which digestion is completed, the amoebocytes transport and supply the digested food to all parts of the body.

- **Respiration-**

The Gaseous exchange occurs by simple diffusion, between the cells of sponge and the current of water. Water entering body is rich in oxygen and facilities exchange of gases. The rate of consumption of Scypha was found to range from 0.16 ml.of oxygen per gram of fresh weight per hour in the smaller specimens to 0.04ml. in the larger ones.

- **Excretion-** While outgoing, water current removes CO_2 and nitrogenous products.
- **Reproduction-**The spermatozoa enters body of other sponges along water current.

3.4.2- Reproduction in *Sycon:*

The sponges reproduce both asexually and sexually.

- **Asexual Reproduction** –Asexual reproduction occurs throughout the Porifera.

The asexual reproduction takes place by budding, regeneration and gemmule formation.

a) **By budding** - During favorable conditions *Sycon* reproduces by budding.

The buds arise basally near its attachment and then constrict off after sometime to lead independent existence.

b) **By regeneration** - Sponges have a great power of regeneration. They not only replace parts lost during injury, but any piece of body can grow into complete sponge.The process is however very slow and is completed in months or years. The regeneration power is used for cultivation of bath sponge industrially.

c) **By Gemmule formation**- Gemmules are not formed in *Sycon*.

- **Sexual Reproduction**

Both male and female gametes are formed inside body of same animal (hermaphrodite) Gametes develop specialized amoeboid cells, called archaeocytes found in mesenchyme.

- **Spermatogenesis-**sperms are produced from amoebocyte or spermatogenesis and get surrounded by one or more flattened cells cover cells. The spermatocyte divides two to three times and cells develop into sperms. Mature sperm has round head with nucleus and long tail (Fig.3.19).

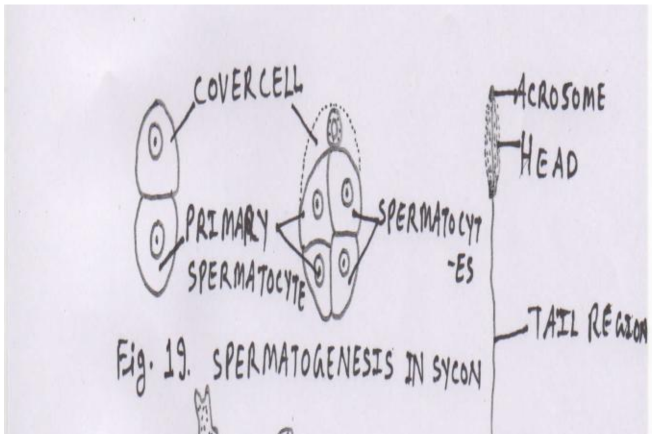


Fig.3.19 Spermatogenesis in Sycon

Oogenesis- Oocyte is differentiated into an enlarged amoebocyte with nucleus. It increase in size, stores food material, is nourished by choanocytes called trophocytes or nurse cells. Its nucleus undergoes two maturation divisions (meiosis) to form ovum (Fig.19).

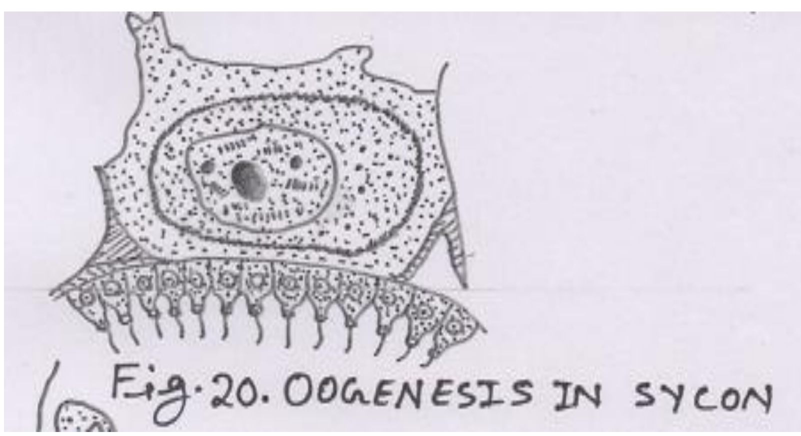


Fig.3.20 oogenesis in Sycon

Fertilization- The fertilization is internal and cross fertilization occurs. The sperm does not enter directly in the ovum but reaches a radial canal and is dispersed by the water currents (Fig.21).

Sperm cell enters the nurse cells or choanocyte adjacent to mature oocytes, which becomes amoeboid and fuses with ovum liberating the sperm. The nuclei of ovum and sperm fuse and form zygote.

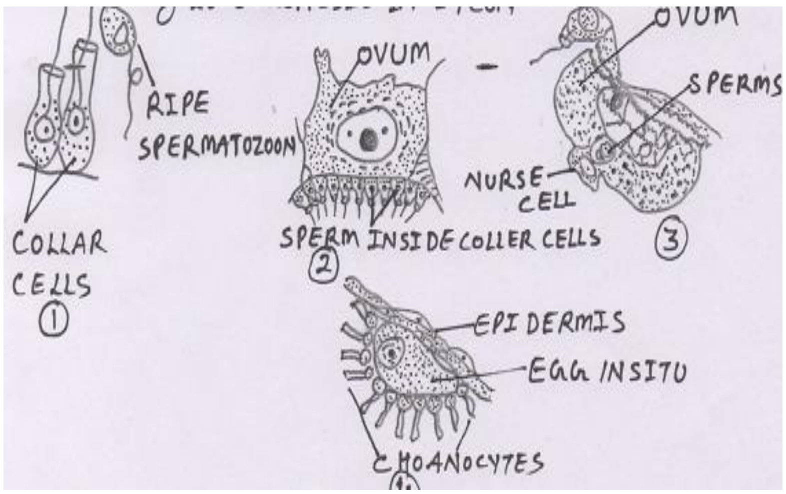


Fig.3.21: Fertilization in Sycon

3.4.3-Development of *Sycon:*

1. Cleavage- The divisions are holoblastic and development occurs inside the body of sponge.

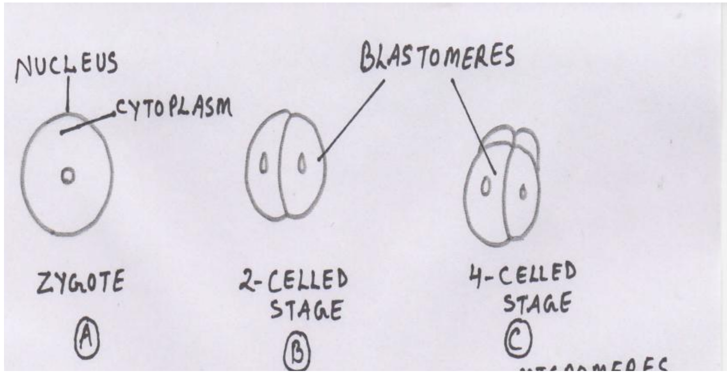


Fig.3.22 Cleavage in Sycon

The 1st three divisions are vertical and produce pyramidal plate of 8 cells.

The 4th division is horizontal and divides blastomeres unequally into 8 micromers and 8 macromers (Fig. 3.22: A to E).

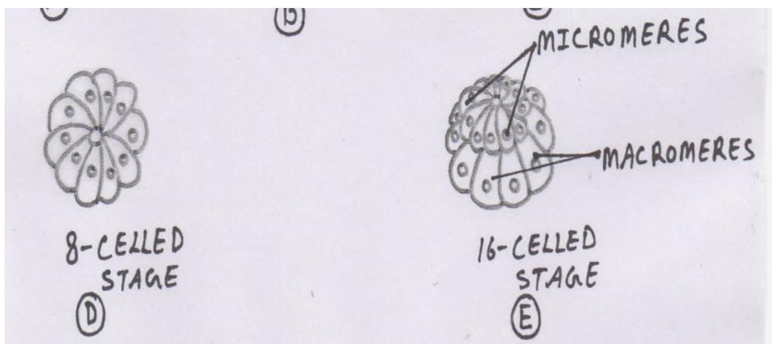


Fig.23 Cleavage in Sycon

A cavity develops in between and embryo enters into the blastula phase. Micromeres divide more rapidly and develop flagella at their free ends, while macromere becomes rounded and represents the stomoblastula.

2. Stomoblastula- one side of stomoblastula is composed of many small, elongated, flagellated micromeres, while other side composed of 8 rounded, non flagellated macromeres (Fig. 3.24: F).

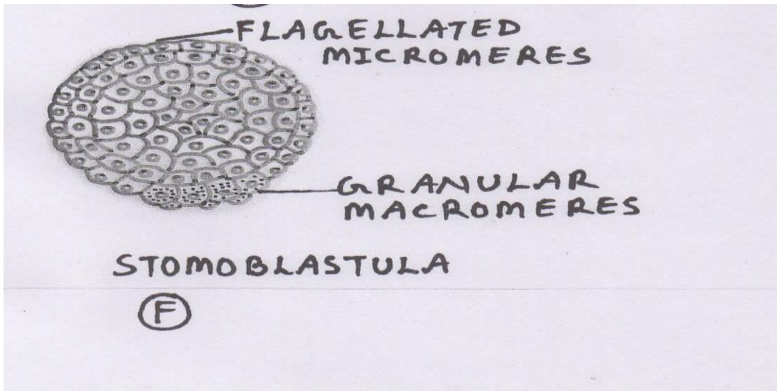


Fig.3.24 Stomoblastula in Sycon

Inner cavity (blastocoel) opens outside through the mouth.

It is used to engulf the surrounding amoebocytes for nutrition.

- **Amphiblastula-** The stomoblastula undergoes inversion and flagellated ends of flagellated cells comes to lie to the exterior.

The flagellated stomoblastula is called amphiblastula larva. The fully formed amphiblastula is set free into radial canal (Fig. 22: G to H).

It escapes by osculum along the water current and leads free swimming existence and undergoes gastrulation by invagination and emboly.The flagellated cell invagination into blastocoel and macromere grows over them by rapid multiplication. Thus gastrula is formed.

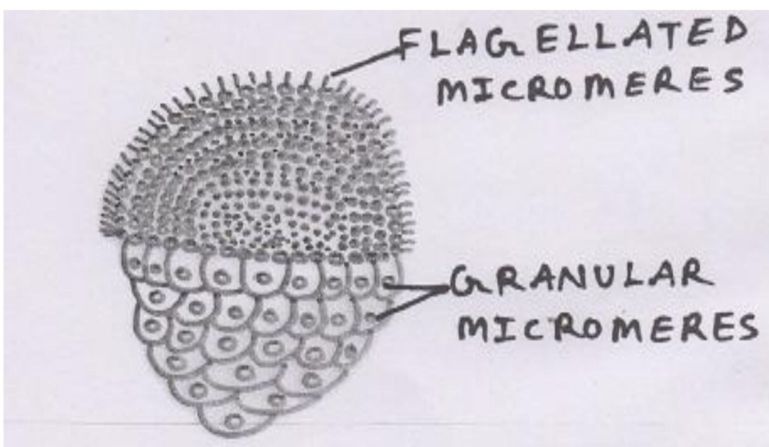


Fig.3.25 Amphiblastula in Sycon

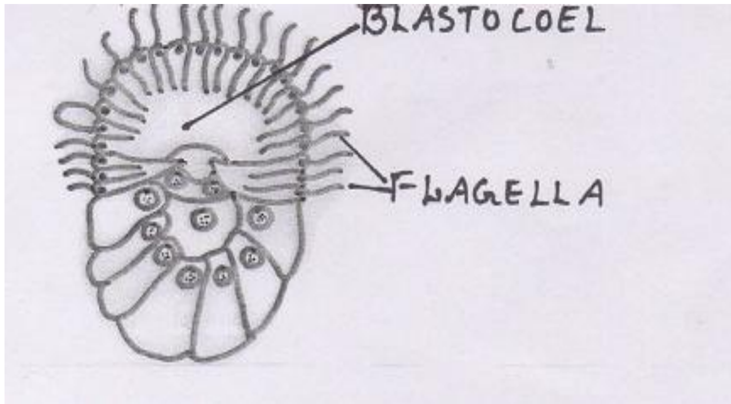


Fig.3.26 Development in Sycon (T.S of Amphiblastula)

- **Gastrula-** Gastrula has two layer bodies.

Outer layer is granular, ectoderm and inner is non-granular flagellated cells, endoderm.

The central cavity opens outside by opening called blastopore (Fig. 3.22: I to J).

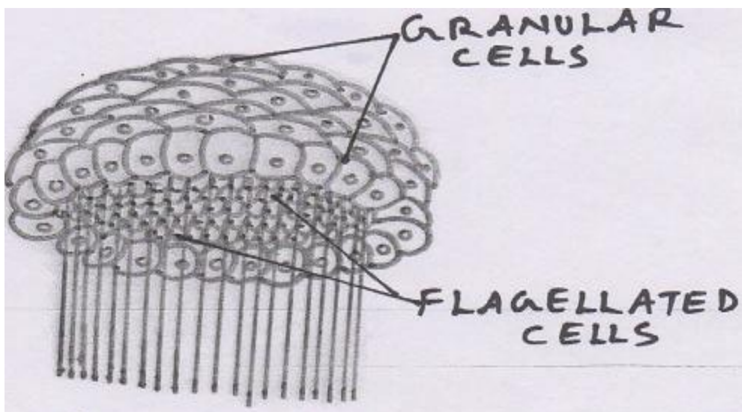


Fig.3.27 Gastrulation in Sycon

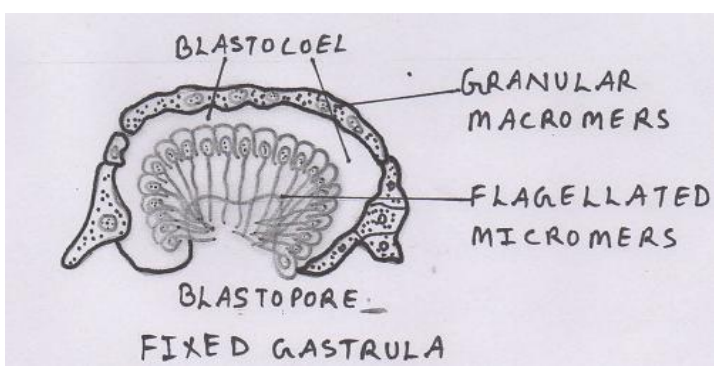


Fig.3.28 Fixed Gastrula

5. **Metamorphosis** **(Post embryonic development)** - The gastrula adheres to substratum like rock, sea weeds, etc., by its blastoporal end and undergoes metamorphosis to form adult *Sycon*.

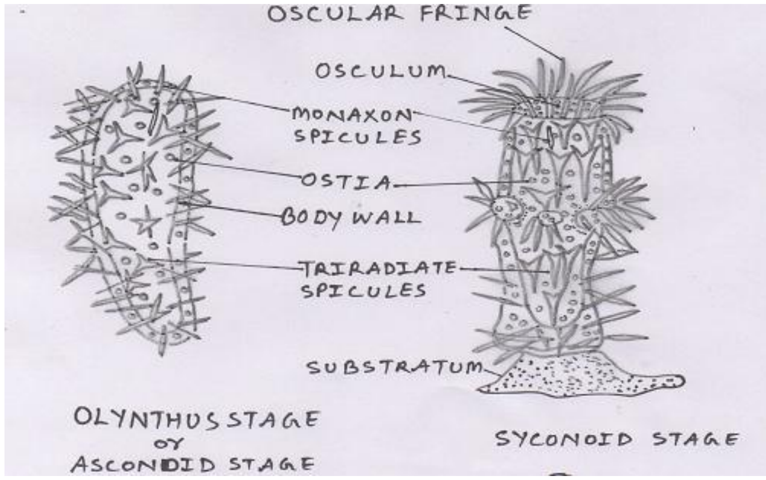


Fig.3.29 Post embryonic development in Sycon

- The larva lengthens into a cylinder and develops osculum at free distal end.
- The non-granular flagellated cells of endoderm form choanocytes.
- The granular non-flagellated cells of ectoderm give rise to pinacocytes of dermal epithelium.
- The body wall gets perforated by Ostia and Olynthus stage is attained by *Sycon* (Fig. 23: K to L). The choanocytes are shifted in these radial canals and the body wall increase in thickness, the adult Scypha is formed and its colony develops.

3.5-Canal system and affinities

Canal system in sponges:

In majority of sponges the body wall is folded and is placed by a complicated system of canals, through by which water current enters the spongocoel. This system of canals is collectively known as canal system.

These are of 3 types in porifera-

1: Asconoid or ascon type of canal system (Fig. 3.29).

2: Syconoid or *Sycon* type of canal system (Fig. 3.30 and 3.31).

3: Leuconoid or leucon type of canal system (Fig.3.32, 3.33 and 3.34).

1: **Asconoid or ascon type of canal system -**

- It is a simplest type of canal system.
- The body is radially symmetrical.
- The body wall of an asconoid sponge is formed of two layers (Outer and inner epithelium).
- Thin walled and vase like with central cavity, the spongocoel opens free end, narrow aperture, the osculum.

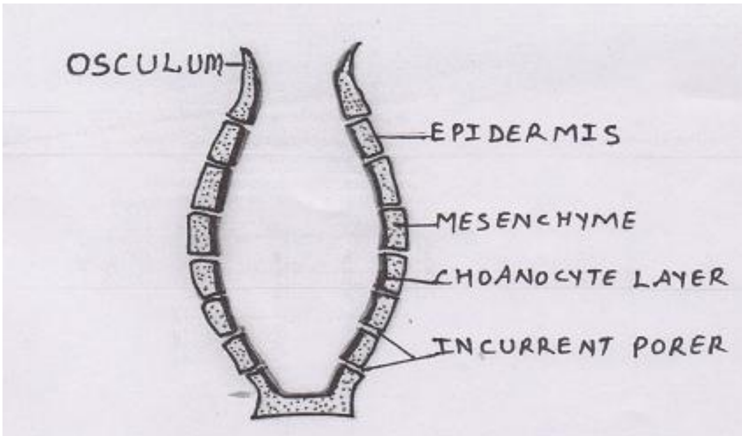


Fig.3.30 Asconoid Types of Canal System in Sycon

The thin wall of cylinder has numerous regularly arranged small intracellular appertures, which are known as inhalants pores or Ostia. Each of them opens in a canal through a tubular porocyte (tubular cell called porocyte). and extends from the exterior to the spongocoel.The water current enters through ostia, reaches the spongocoel and finally leaves the body through osculum. The outer ectoderm is formed of pinacocytes while the inner endoderm of loosely arranged choanocytes.

2. **Syconoid or *Sycon* type of canal system**

It's theoretically derived from asconoid type by out pushing its wall into finger like structures. These structures are lined by choanocytes and are called as radial canals. The wide opening between two radial canals forms ostium and space is called as incurrent canal.

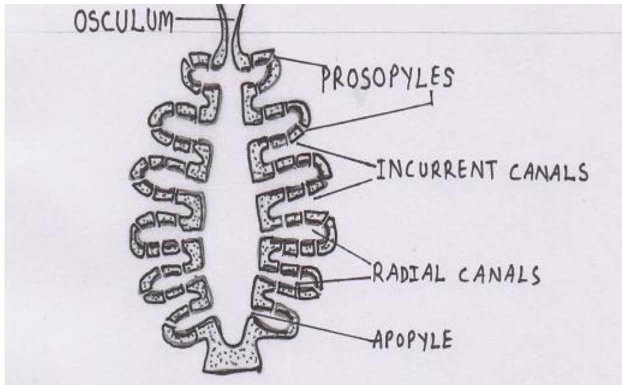


Fig.3.31 Syconoid Types of Canal System in Sycon

The water current in Syconoid sponges takes the following route: dermal pores → in current canals → prosopyles → radial canals → internal ostia (apopyles) → spongocoel → osculum → out.

The Syconoid sponges differ from the Asconoid type in two important particulars:-

(a) - The thick folded walls containing alternating incurrent and radial canal.

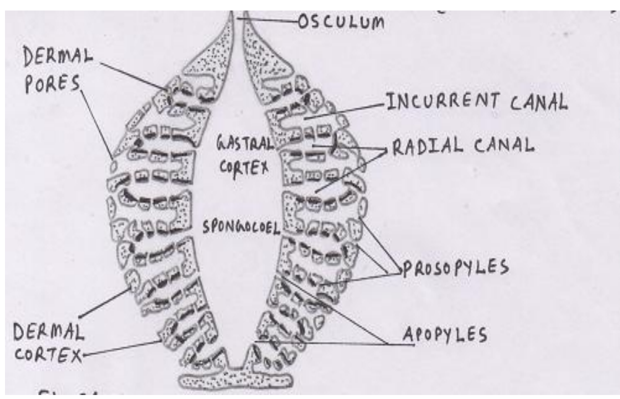


Fig.3.32 Final Syconoid Canal System in Sycon (with cortex)

b) - The breaking of the choanocyte layer, which no longer lines the whole interior but is limited to certain definite chamber(radial canals).

Syconoid structure occurs in two main stages-

- In its simplest form the radial canal extends out freely to exterior and do not touch each other at any point so that water surrounds the sponge body.

- In complex form the epidermis and mesenchyme spread over the outer surface forms cortex which may be thin and becomes thick in still more complex forms. The wide space between radial canals has tubular appearance and forms in current canals. The epidermis at distal end has pores known ostia by which water enters inside. E.g-Sycon (Fig.25 and 26).

3. Leuconoid or leucon type of canal system:

The more complex leuconoid structure develops by further out folding of the radial canals of Syconoid stage and thickening of mesenchyme. Radial canals are replaced by clusters of small rounded flagellated chambers.

The mesenchyme fills space between flagellated chambers, so that sponge assumes irregular shape. Its interior has network of channels.These are excurrent channels between radial canals.

The excurrent canal from different radial chambers opens into wider chambers and finally to exterior osculum. Similarly incurrent canal also gets branched and irregularly arranged. The dermal ostia may lead directly into incurrent canals or open into subdermal spaces crossed by spicules.

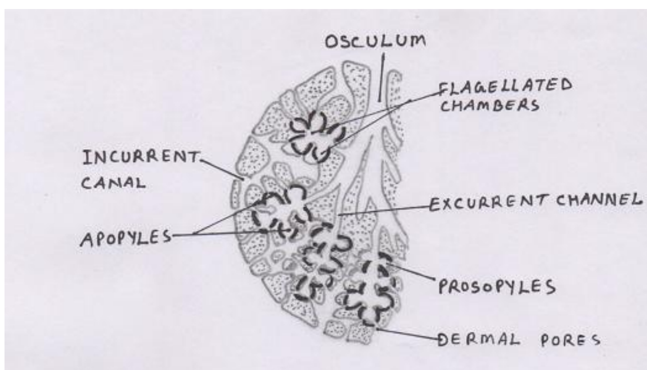


Fig.3.33 Leuconoid type of Canal System in Sycon

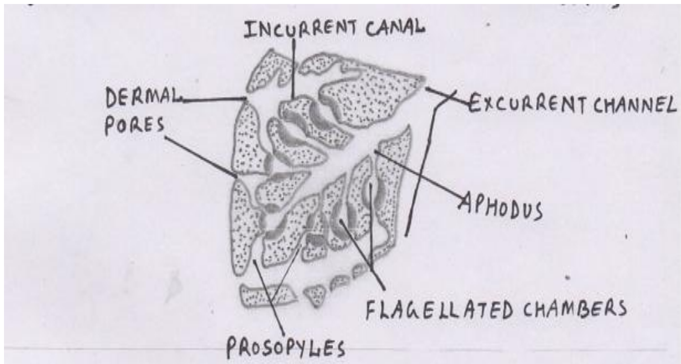


Fig.3.34 Leuconoid type of Canal System in Sycon (Aphodal Chamber)

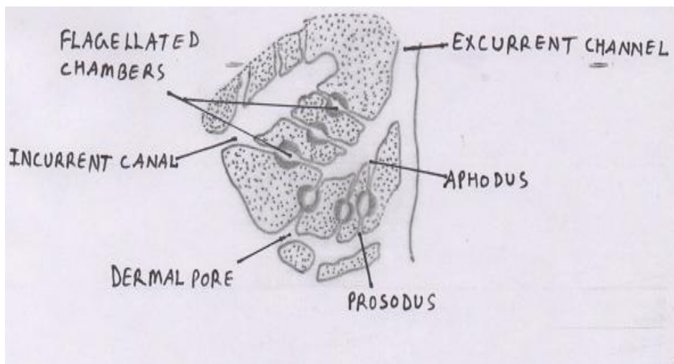


Fig.3.35 Leuconoid type of Canal System in Sycon (Diplodal Chamber)

The special features of the leuconid type of canal system are the limitation of the choanocytes to small chamber, the major development of the mesenchyme, and the complexity of the incurrent and excurrent canals.The leuconid type of canal system exhibits numerous variations but present three stages of evolution, viz., eurypylous, aphodal and diplodal (Fig.3.27, 3.28 and 3.29).

(a)- **Eurypylous-** In this type of canal system, the flagellated chamber is wide and thimble – shaped, each opening directly into the excurrent canal by a wide aperture called apopyle and receive the water supply direct from the incurrent canal through the prosopyle. Eg. *Leucilla* (Fig.3.27).

(b)- **Aphodal-** In this type of canal system, the flagellated chamber is small and rounded. The opening of each flagellated chamber into the excurrent canal is drawn out into a narrow tube, usually not of great length, known as aphodus. E.g. *Geodia* (Fig.3.28).

(c)- **Diplodal-** In this type of canal system, a narrow current tube, the prosodus between the incurrent canal and the flagellated chamber, this type of situation are known as diplodal. This type of canal system is found in *spongilla* (Fig.3.29).

Table1: Different kinds of sponge structure.

	Asconoid	***Sycon*oid**	**Leuconoid**
Sponge wall	Simple	Out folded with alternating radial and incurrent canals	Irregular
Choanocytes	Lining central spongocoel	Lining radial canal	Restricted to flagellate chambers
Mesenchyme	Limited amount, simple layer completely traversed by porocytes	Increased in thickness. No longer completely traversed by porocytes	Highly developed
Direction of water current	In-current pores ↓ Spongocoel ↓ Osculum	Dermal pores ↓ In-current canals ↓ Prosopyles ↓ Radial canal ↓ Apopyles spongocoel ↓ Osculum	Dermal pores ↓ Subdermal spaces ↓ In-current channels ↓ Prosopyles ↓ Flagellate chambers ↓ Apopyles ↓ Excurrent channels ↓ osculum

Affinities:

There has been a great controversy over the nature and affinities of sponges ever since they were discovered. Aristotle (384-322 B.C.) was the first to recognise them as animals. Phylum Porifera shows affinities with protozoa as well as with metazoa.

1. AFFINITIES WITH PROTOZOA

(a) Resemblance with protozoa

- Intracellular digestion and absence of definite and digestive system.
- Production of skeletal spicules by cells.
- Presence of collar cells and amoeboid cells.
- The cells of sponge body are interdependent in their function.
- Inversion process occurs in amphiblastula larva like those of volvox.

(b) Differences with protozoa

- Sedentary in habitat.
- Diploblastic acoelomates with absence of cellular mesenchyme.
- Development of multicellular organization by cleavage of fertilised egg.
- Possession of a canal system and skeleton made of spicules.
- Differences between characteristic feature of skeleton and canal system
- Development of specialised cells such as pinacocytes, choanocytes and porocytes show division of labour in somatic cells. Thus, sponges are more complex than a colony of protozoans but resemble multicellular metazoa.

2. AFFINITIES WITH METAZOA

(a) Resemblance with metazoa

- Both are sedentary in habit.
- Both are diploblastic and acoelomate.
- Both reproduce asexually and form colonies.
- Both sponges and coelenterates show the presence of same nucleic acids and amino acids.
- Parenchymula larva of sponges resembles planula larva of coelenterates.
- Spongocoel in sponges opening out through osculum can be compared with gastro-vascular cavity of coelenterates opening out through mouth.

(b) Differences with metazoa

- In sponges, cells are less specialised and less independent than those of metazoa.
- Sponges do not have anterior end though osculum serves physiologically as controlling region.
- Primary openings are not present as osculum in sponges.

- Body surface is perforated by inhalent pores or ostia extend by water channels, a unique feature of sponges only.
- Tissue formation is restricted to the formation of epithilial lining on the surface. There are no organs as found in higher animals.
- Sponges lack true mouth. Osculum does not correspond with the mouth of coelenterates.
- Stinging cells are found in coelenterates are lacking in sponges.
- Nervous system is lacking in sponges.

3.6- Self assessment question

Q.No. 1. Describe various types of canal systems found in sponges.

Q.No. 2. Which sponge is commonly known as Dead Man's Finger?

Q.No.3. what is the economic importance of Euplectella and Euspongia? What is their significance?

Q.No.4. Write short on:
(1) Euplectella; (2) Hyalonema;
(3) Spongilla (4) Chalina;
(5) Euspongia; (6) Cliona.

3.7- References

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3.11. Terminal Questions

1. Write the outline classification of Phylum Porifera?

2. Into how many classes is Phylum Porifera divided? Write their names and important characters?

3. What is the characteristic feature of phylum Porifera? What is its importance?

4. on basis of which characters is the classification of Porifera based?

Multiple Choice Questions:

1. Most primitive group of animals, which are multicellular, is

(a) Coelenterata [ ] (b) Colonial protozoans [ ] (c) Sponges [√] (d) Nemertine. [ ]

2. In class demospongiae, leucon type of canal system is derived from

(a) Ascon type of canal system of larva [ ] (b) *Sycon* type of canal system of larva [ ]

(c) Rhagon types of canal system of larva [√] (d) all of the above. [ ]

3. Animal of phylum Porifera are characterised by

(a) Gland cells [ ] (b) Choanocytes [√] (c) Amoeboid cells [ ] (d) Pigment cells.[ ]

4. Ascon type of canal system is found in

(a) Euspongia [ ] (b) Leucosolenia [√] (c) Grantia [ ] (d) Hyalonema. [ ]

5. Which one of the sponge is harmful to the oyster industry?

(a) Cliona [√] (b) Euspongia [ ] (c) Spongilla [ ] (d) Hyalonema. [ ]

6. 'Venus Flower Busket' is the name of the dried skeleton of

(a) Euspongia [ ] (b) Spongilla [ ] (c) Euplectella [√] (d) Leucosolenia [ ]

7. Which of the following is a freshwater sponge?

(a) Spongilla [√] (b) Euplectella [ ] (c) Euspongia [ ] (d) *Sycon*. [ ]

8. The simplest type of canal system in Porifera is

(a) Leucon type [ ] (b) Radial type [ ] (c) Ascon type [√] (d) *Sycon* type [ ]

9. Porifera is characterised by the presence of

(a) Paragastric cavity [√] (b) Coelenteron [ ](c) Coelom [ ] (d) Water vascular system[ ]

UNIT: 4 PHYLUM COELENTERATA

4.1-Objectives

(1)-Understanding the general characters and classification up to order level, Aurelia with special reference to structure, reproduction, development and polymorphism.

(2)-To understanding the coral, coral reefs and their economic importance.

4.2-Introduction

Phylum Cnidaria (formely known as coelenterata) includes about 9000 species. Some are found in fresh water, but the greater numbers are marines. Coelenterates (Gr. koilos- hollow + enteron-gut) are the simplest of eumetazoans. This interesting group of animals takes its name from the large cavity in the body that serves as the intestine. They include the hydra, jellyfish, sea anemones and corals.

4.3- General characters and classification up to order level

4.3.1-General Characters:

- Coelenterata are metazoa or multicellular animals with tissue grade of organisation.
- 2Body radial or bi-radially symmetrical with oral-aboral axis.
- 3They are diploblastic animals.
- Coelenterate animals are represented by two morphologically different types of individuals, polyps and medusa.
- Polyps are sessile (attached to the substratum) with a tubular body (eg. *Hydra*). Whereas medusa are free-swimming with an umbrella or bell-shaped body, eg. *Aurelia*, *Metridium*.
- They are all aquatic, mostly marine and some freshwater (eg. *Hydra*).
- They may exhibit solitary or colonial habitat.
- One of the most characteristic structures of all coelenterates is the stinging cells, called nematocysts.
- Nematocysts serve for adhesion, food capture and offence and defence.
- They have a single gastro-vascular cavity, into which mouth opens.
- Short and slender tentacles encircle the mouth in one or more whorls.
- Coelenterate animals are usually carnivorous.

- The coelom, excretory, circulatory and respiratory organs are absent.
- Anus is absent.
- Locomotion is brought about by smooth muscle fibers.
- Nervous system consists of one or more networks or nerve cells and neurites located in the ectoderm and endoderm.
- Sense organs are ocellii and statocysts.
- Skeleton either calcereous or horny and external or internal but absent in few.
- Reproduction is both asexual and sexual methods.
- Asexual reproduction occurs by budding and sexual reproduction by the formation of gametes.
- The Planula larva present in the life history of Coelenterata.
- The life history exhibits the phenomena of alternation of generations or metagenesis in which the asexual polypoid, sessile generation alternates with sexual medusoid, free-swimming generation.

4.3.2-Classification up to order level

- Phylum Coelenterata was classified by L.H. Hyman in 1940.
- Phylum Coelenterate includes nearly 11,000 known species half of which are extinct.
- Phylum Coelenterata has been divided into three classes as follows:-

PHYLUM-COELENTERATA

Class 1.Hydrozoa

(Gr., hydra- water + zoon- animal)

- Hydrozoa mostly colonial and marine.
- Some hydrozoa are solitary and freshwater.
- They exhibit tetramerous or polymerous radial symmetry.
- Gastro-vascular cavity without stomodaeum, septa or nematocysts bearing gastric filament.
- They exhibit either only polyps or both asexual polyps and sexual medusa form.
- Gonads are epidermal in origin.

- Sex cells are shed directly to the outside.
- The cleavage pattern is holoblastic, embryo ciliated planula.

It includes following orders:

- ❖ **Order1:** Hydroidea
    - They may be solitary or colonial.
    - The medusae form is absent or short-lived.
    - The sense organs are exclusively ectodermal.
- o **Sub-Order (a)-Anthomedusae**

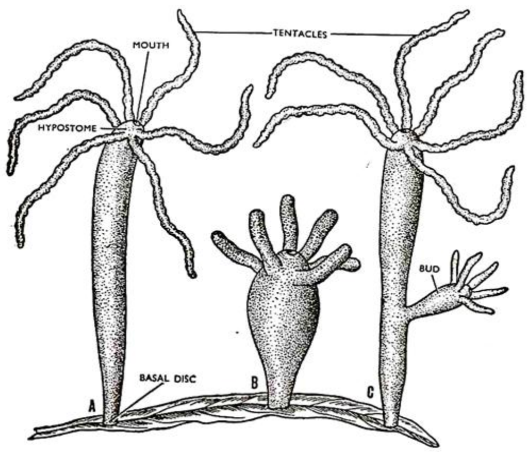


Fig.4.1 Hydra

- Colonial or solitary.
- Polyps are not enclosed in hydrothecae.
- The medusae are naked without gonothecae.
- Medusae are tall and bell like.

Eg.- *Hydra* (Fig.1) and *Tubularia*.

- o **Sub-Order (b)-**Leptomedusae
    - Colonial Hydrozoa.
    - Polyps are enclosed in hydrothecae.
    - The medusae are covered with gonothecae.
    - Eye spots or ocelli are absent.

Eg.-*Obelia* (Fig.2).

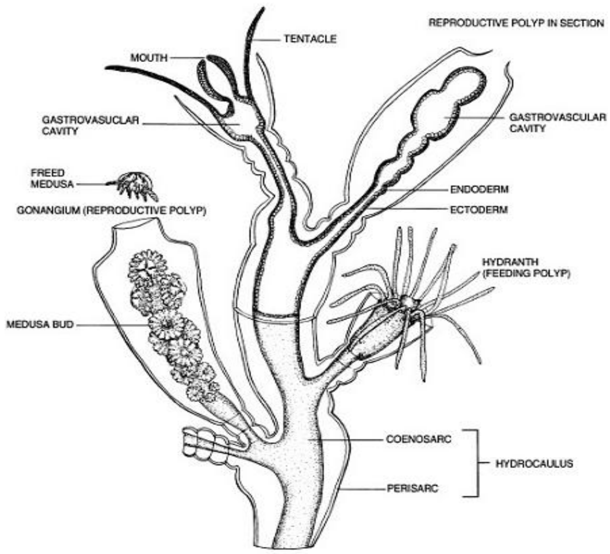


Fig.4.2 Obelia

❖ **Order2:** Trachylina

- Polypoid stage is absent or reduced.
- The medusoid stage is large, dominant and free-swimming.
- They may develop directly from fertilized egg by which the polyploidy stage is reduced or absent.
- Sense organs or statocysts with endo-dermal statoliths.

o **Sub-Order (a)- Trachymedusae**

- Margin of the umbrella is smooth.
- Gonads borne on the radial canals.
- Manubrium is long.

E.g. *Geryonia*.

o **Sub-Order (b)-Narco medusae**

- Manubrium is short.
- Gonads borne in the floor of the stomach.

Eg. *Solmaris*

❖ **Order3:** Hydrocorallina or Milleporina

- Colonial coral like Hydrozoa without perisarc.
- These are fixed, colonial polyploid hydrozoa in which coenosarc secretes a massive exoskeleton of calcium carbonate

- Colonies have two kinds of zooids, the gastrozooids and dactylozooids.

E.g. *Millepora*.

❖ **Order4:** Siphonophora

- These are pelagic colonial hydrozoa showing extreme polymorphism of zooids,
- Polyps are without oral tentacles.
- Medusae are incomplete and rarely freed.

o **Sub-Order (a)-**Calycophora

- Upper end of the colony is provided with one or more swimming bells.
- Apical float or pneumatophore absent.

E.g. *Diphyes*.

o **Sub-Order (b)-**Physophorida

- Upper end of the colony bear a float or pneumatophore.

E.g. *Velella*

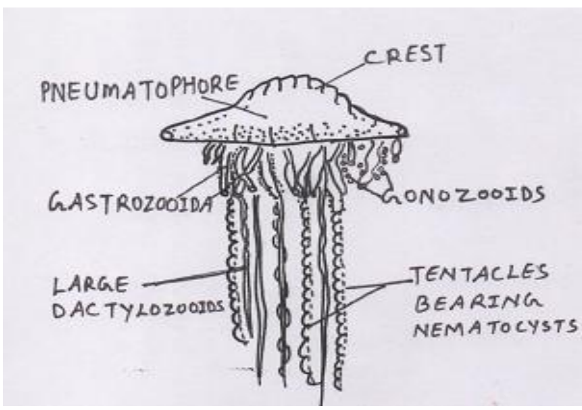


Fig 4.3 Physalia

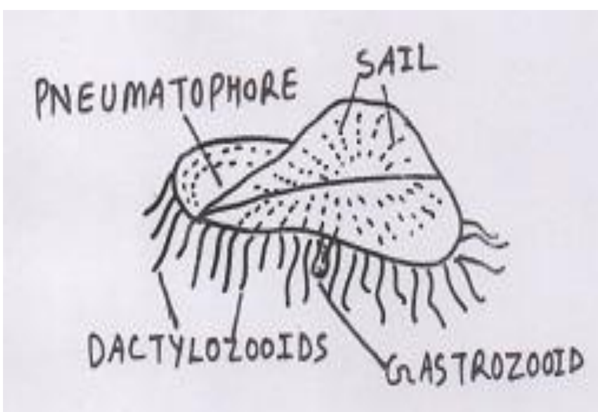


Fig.4.4 Velella

Class 2.Scyphozoa:

(Gr.Skyphos-cup + zoios-animals)

- They are exclusively marine and solitary forms.
- The medusa stage is dominant but the polyp stage reduced or absent.
- The gonads are gastro-dermal and sex cells are shed or released in digestive cavity.

❖ **Order(a):** Stauromedusae (lucernariida)

- These are bell-goblet or trumpet-shaped.
- All are sessile, attached by an aboral stalk.

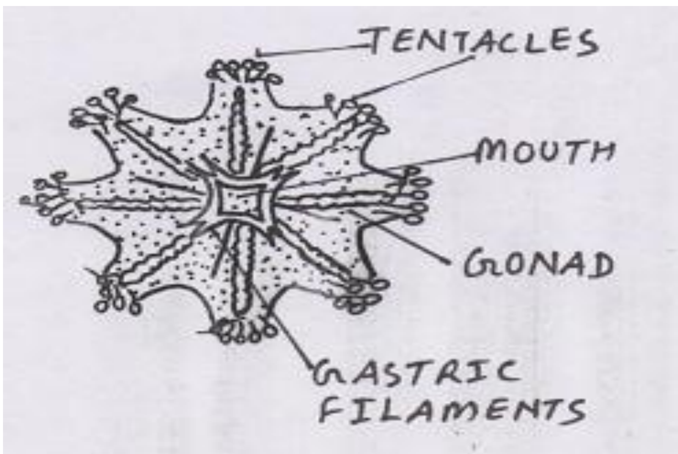


Fig.4.5 Lucernaria

- Mouth cruciform (four cornered) with small oral lobes.
- They have no marginal sense organs or tentaculocysts.
- Fertilization is external.
- Planula larva without cilia.

E.g. *Lucernaria* (Fig.5) and *Haliclystus*.

❖ **Order (b):** Cubomedusae (Carybdeida)

- Free-swimming Scyphozoa found in warm and shallow water of tropical and subtropical region.
- They are bell-cubical, with 4 flattened sides.
- Four per-radial tentaculocysts are present.
- Gonads are life like structure.

E.g. Charybdea and Chiropsalmus.

❖ **Order(c):** Coronatae

- Free-swimming Scyphomedusae found inhabiting the deep water of ocean.
- They are bell-conical, divided by a deep circular coronary groove.
- Tentacles are long, born on pedalia.
- Four to sixteen tentaculocysts present.
- Mouth is cruciform.

  E.g. Periphylla and Pericolpa.

❖ **Order(d):** Semaeostomeae (Discomedusae)

- Most common free-swimming medusae found inhabiting the coastal water of all oceans.
- Gastric pouches and filaments are absents.
- They have flat saucer or disc-like umbrella.
- Eight tentaculocysts present.
- Mouth extending into 4 long oral arms.

  Eg. Aurelia (Fig.6), Pelagia and Cyanea (7) & Chrysaora

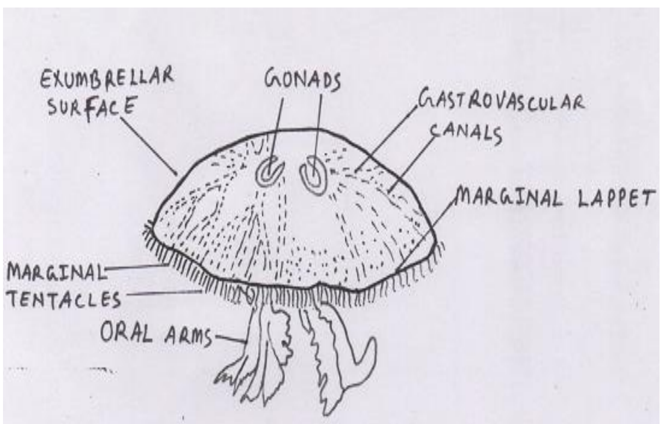


Fig.4.6 Aurelia

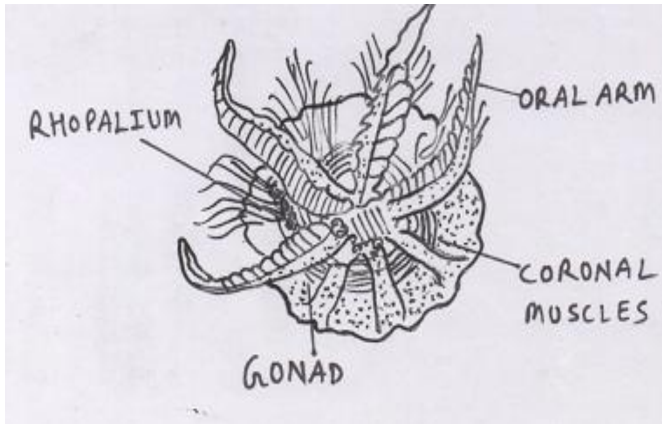


Fig.4.7 Cyanea

❖ **Order(e):** Rhizostomae

- Free-swimming Scyphozoa found in shallow water of tropical and subtropical oceans.
- Bell-shaped usually hemispherical, without marginal tentacles.
- Typically 8 or more tentaculocysts.
- No central mouth but the oral arms is fused with several small mouths.

  E.g. Rhizostoma and Stomolophus.

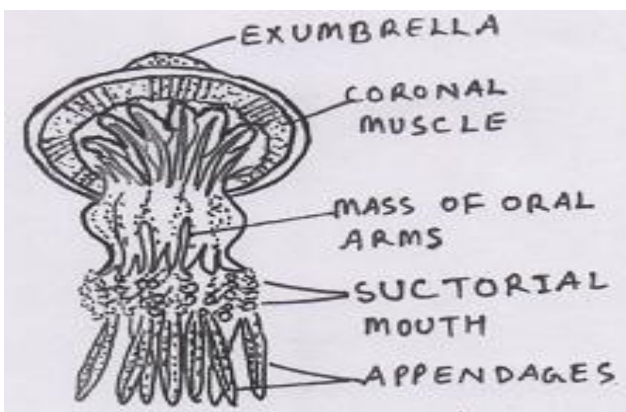


Fig.4.8 Rhizostoma

Class 3.Anthozoa (Actinozoa):

(Gr.Anthos- flower + zoios- animal)

- They are exclusively marine, may be solitary or colonial.
- All are polyp forms, nomedusae.
- They have gastro-dermal gonads.

- Gasto-vascular cavity is divided into completed and incomplete septa.
- Skeleton either external or internal.
- Nervous system prepared by typical nerve net without a concentrated central nervous system.
- Fertilisation is external.

These are divided into three subclasses:

- **Subclass 1.Octocorallia (Alcyonaria)**
  - They are exclusively colonial.
  - These are found in polyp form with 8 pinnate tentacles and 8 septa.
  - Eight complete mesenteries are present.
  - Polyps are dimorphic in some forms.
  - They include six orders:-

❖ **Order(a):** Stolonifera

- The stolonifera are inhabitants of shallow waterin the tropical and temperate area.
- The polyps arise independently from a creeping motor stolon.
- The skeleton of separate calcareous spicules or absent.\
  E.g. *Tubipora* and *Clavularia*

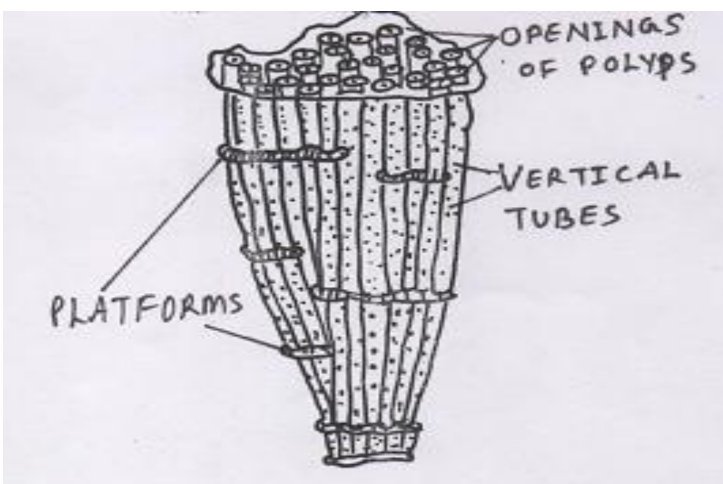


Fig. 4.9 Tubipora

❖ **Order (b):** Telestacea

- Lateral polyps on simple or branched stems arising from a creeping base.

- Skeletal consists of spicules fused by calcareous.

  E.g. *Telesto*.

❖ **Order(c):** Alcyonacea

- Colony mushroom-shaped.
- Polyps are dimorphic in some forms (Autozooides and Siphonozooides)
- Polyps proximally embedded in a fleshy mass or coenenchyme.
- Skeleton of separate calcareous spicules.

  E.g. Soft corals and *Alcyonium.*

❖ **Order(d):** Coenothecalia

- Polyps embedded and connected by solenial tubes.
- Skeleton massive, calcareous and blue-green from iron-salts.

  E.g. *Heliopora* (Blue coral).

❖ **Order(e):** Gorgonacea

- Colony usually of plant like branching forms bearing short polyps.
- Axial-skeleton composed of horn-like Gorgonin.
- It is commonly known as sea fans.
- Separate or fused calcareous spicules or both.

  E.g. *Gorgonian* (Fig.10) and *Corallium*

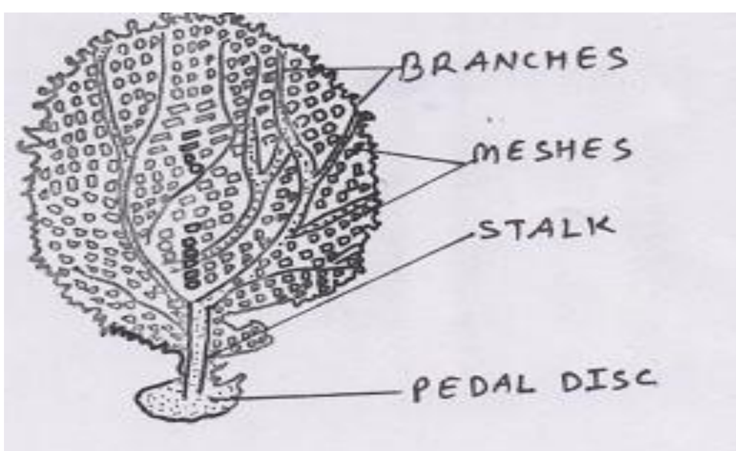


Fig.4.10 Gorgonia

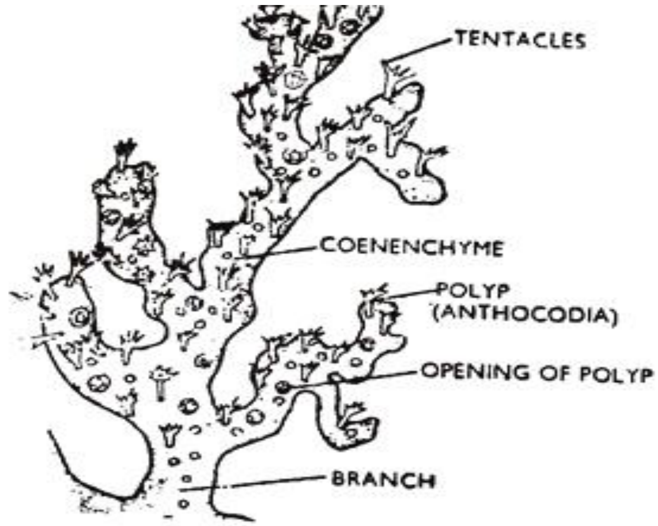


Fig.4.11 Corallium

❖ **Order(f):** Pennatulacea

- Colony elongated, sessile.
- Lower part embedded in mud.
- Upper parts consist of very long axial polyp with lateral branches bearing dimorphic polyps.
- Axial skeleton of separate calcareous spicules or horny substance.

Eg. *Pennatula* (Fig.12) and *Renilla* (Sea pansy).

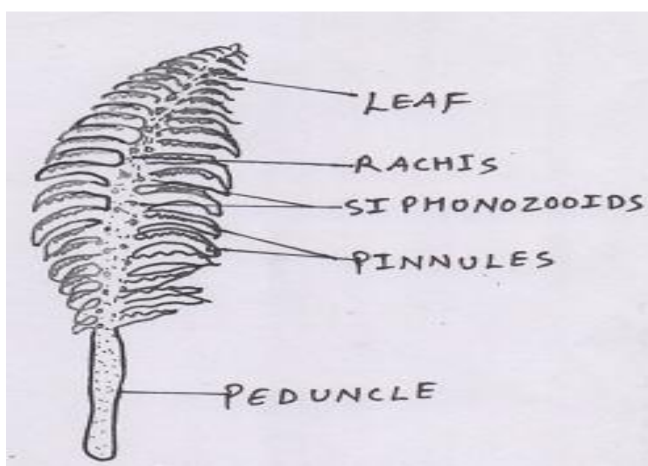


Fig.4.12 Pennatula

o **Subclass 2. Hexacorallia (Zoantharia)**

- They may be solitary or colonial.

- The tentacles are usually unbranched, numerous arranged in the multiple of 5 to 6 but never 8.
- Endoskeleton is calcareous type. Polyps are monomorphic.
- They included five orders:

❖ **Order (a):** Zoanthidea

- They may be solitary or colonial.
- No skeleton but body wall may contain calcareous bodies.
- Polyps are small in size.
- Mesenteries are paired.

E.g. *Zoanthus* and *Epizoanthus*

❖ **Order (b):** Actiniaria

- Colonial or solitary.
- Skeleton absent.
- Tentacles and mesenteries are numerous.
- Large sized solitary anemones.
- Body muscular, often with an aboral pedal disc.

Ex. Sea-anemones (Fig.13), Metridium and Actinia.

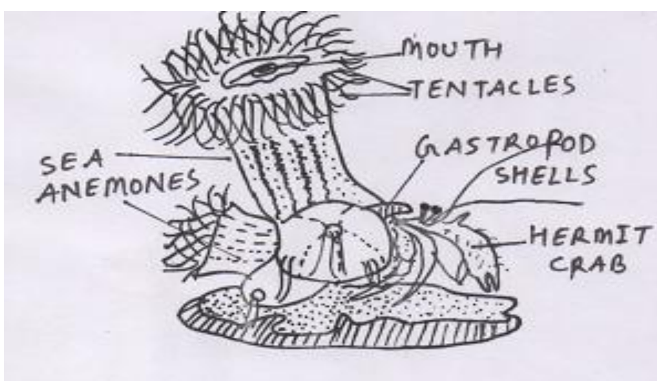


Fig.4.13 Sea-anemones

❖ **Order(c):** Ceriantharia

- Long, solitary, anemones like form living in sea bottom.
- Body smooth and cylindrical.
- Without pedal discs and skeleton.

- Tentacles numerous, arranged in to whorls- oral and marginal.

  E.g. Cerianthus.

❖ **Order (d):** Antipatharia

- Antipatharia showed plant like colonial forms.
- It is found in the deep sea
- Tentacles and mesenteries comparatively few (6 to 24) in number.
- Skeleton as branched, chitinoid axis.

  E.g. Black corals and Antipathes.

❖ **Order (e):** Madreporaria

- Generally found in colonial forms.
- Exoskeleton is hard, compact, often massive and calcareous.
- Polyps are small living in cup like cavities on exoskeleton.

  E.g. True or stony corals, Astraea and Acropora or Madrepora (Stag Hor n coral.

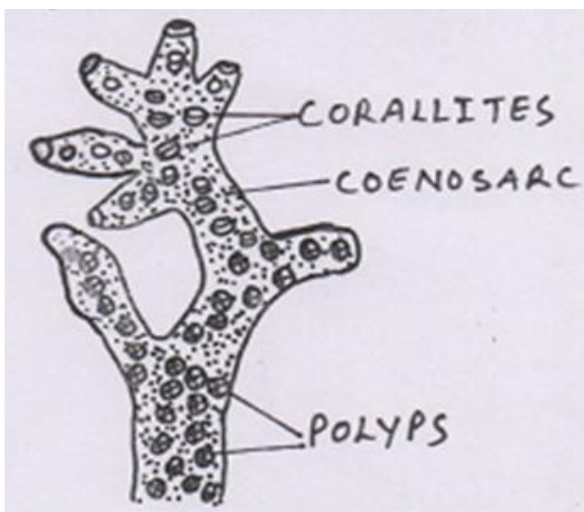


Fig.4.14 Madrepora

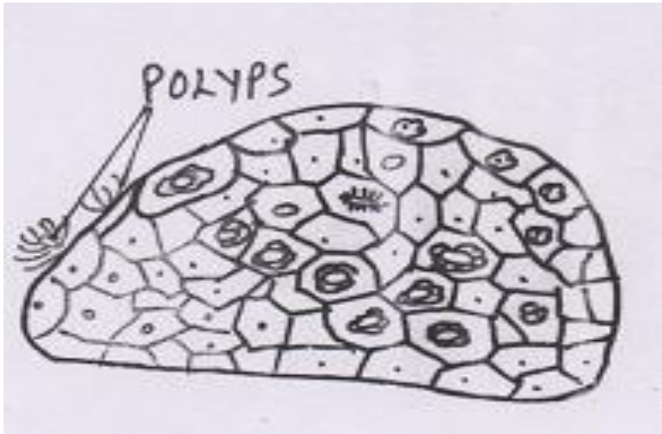


Fig.4.15 Astraea

- **Subclass 3.** Tabulata
    - These include extinct colonial anthozoans with heavy calcareous skeletal tubules containing horizontal platforms or tubulae.

    E.g. Favosites and Halysites.

4.4- Aurelia with special references to:-

4.4.1-Reproduction:

Aurelia (A jelly-fish):

Jelly-fishes are animals which belong to class Scyphozoa of Phylum Coelenterata. In this class, medusa is dominant and conspicuous zooids in life cycle while polypoid form is restricted to a short larval stage.

Aurelia aurita

A jelly-fish is not a true fish which is a vertebrate animal with a backbone.

Systematic position:

PHYLUM COELENTERATA
CLASS SCYPHOZOA
ORDER SEMAEOSTOMAE
FAMILY ULMARIDAE
GENUS AURELIA
Species aurita

Habit and Habitat:-

- Aurelia aurita is also popularly known as “moon-jelly”.
- It is cosmopolitan jelly-fish, occurring in warm and temperate seas all over the world.
- It lives in coastal waters singly or in large shoals.
- It is found either floating with water currents and waves or swimming feebly by the contraction movements of its bell.
- It is carnivorous.

External Features:-

(a)Shape

Aurelia aurita resembles to a hydrozoan medusa.

The medusa of Aurelia aurita is flattened, bowl or saucer-shaped gelatinous structure called the umbrella (Fig.16).

(b)Size

The size is usually 4-12 inches in diameter.

(c)Colour

The umbrellar is almost transparent and bluish-white reddish or pinkish gonads.

(d)Structure

- The structure is distinctly divided into a slightly convex upper surface and a concave lower surface (Fig.4.16).

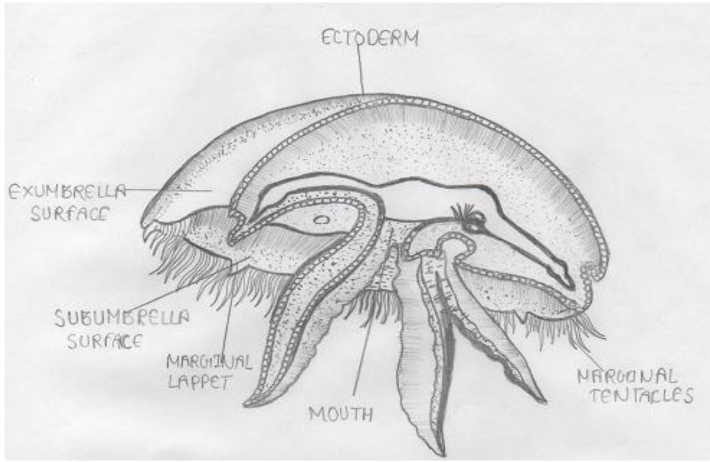


Fig.4.16 Aurelia Aurita (Side View)

- The convex surface is known as exumbrellar surface and concave surface is known as subumbrellar.
- The margin of umbrella is circular which is broken by eight notches.
- Each notch carries a sense organ, the tentaculocyts or rhopalium, protected by two leaves- like processes the marginal lappets.
- The marginal flap is known as velarium or pseudovelum.
- The true velum is not present in Aurelia.
- Muscles and nerve ring is absent in Aurelia.
- The following structures are found on the subumbrellar surface:-.

(i) Manubrium- In the centre of the subumbrellar surface, there is well developed but short and inconspicuous manubrium bearing a large squarish mouth.

(ii) Oral arms-The four corners of the mouth are drawn into four long delicate oral arms, Each arm bears a ciliated groove.

(iii) Subgenital pits- Situated ventrally between the oral arms and at a short distance from the mouth are four rounded apertures which lead into four subgenital pits.

(iv) Gonads- The gonads are four horse shoe-shaped patches of red or pink colour occupying inter-radial position.

Internal Anatomy:

(A) Body wall

The body wall is diploblastic, having the ectoderm, endoderm and mesogloea.

(1) Ectoderm- The ectoderm or epidermis covers the bell or umbrellar all around.

It has the columnar epitheliomuscular cells, nerve cells, sensory cells, which produce mucus. The manubrium and oral arms are also lined by epidermal cells.

(2) Endoderm- The endoderm or gastrodermis has columnar ciliated epithelial cells, they have no muscle processes, and the endoderm lines the enteron except the gullet.

(3) Mesogloea-It forms the bulk of body.

- It forms a thick layer between epidermis and gastrodermis.
- It is not structureless.
- It contains numerous branching elastic fibers and wandering amoeboid cells.
- This type of mesogloea is known as collenchyma.

(B) Muscular System

- It is very well-developed and confined to subumbrella surface.
- It is formed of both striated and non-striated muscle fibres.
- The muscle fibres are arranged longitudinally in the tentacles, manubrium and oral arms but are radial and circular in the umbrella.
- The rapid and rhythmic contraction of these muscle processes brings about swimming movements in Aurelia.

(C) Gastro-vascular System

- The mouth leads into the short gullet within the manubrium which finally opens into a four lobed spacious stomach.
- The digestive system has also taken over the work of distribution of digested food.
- Hence a distinct circulatory system is absent and this system is called gastro-vascular system.

(D)Nervous System

- The nervous system forms a subumbrella plexus and group of eight rhopalial ganglia.
- The subumbrella plexus froms special radial thickenings.

- The marginal nerve ring is either absent or faintly developed.

(E) Sense Organs

- Sense organs of Aurelia are eight rhopalia or Tentaculocyst situated in the eight marginal notches.
- Several sense organs are localized near the tentaculocyst.
- There are two olfactory pits as depression, one on the ex-umbrella and the other internal to the Tentaculocyst, their sensory epithelium is olfactory.

(F) Reproductive Organs

- The male and female sex organs are borne on separate sub umbrella which are similar in appearance.
- The gonads are horse –shoe-shaped, plaited or frilled structures of brilliant pink or reddish violet colour shining externally through semitransparent membrane of umbrella.

Reproduction and Life History:

- *Aurelia aurita* is dioecious, that is, the male and female sexes are separate but there is no sexual dimorphism.

Sex organs:

- Testes and ovaries are similar in appearance.
- A medusa has four horse-shoe-shaped gonads lying on the floor of stomach periphery, that is, one in each gastric pouch.
- They are reddish violet in colour.
- On maturity, ova and sperms break into the gastro-vascular cavity and pass out of mouth with the outgoing water current.
- The ova or eggs are lodged in the frills of oral arms.

4.4.2- Development of *Aurelia*

Fertilization:

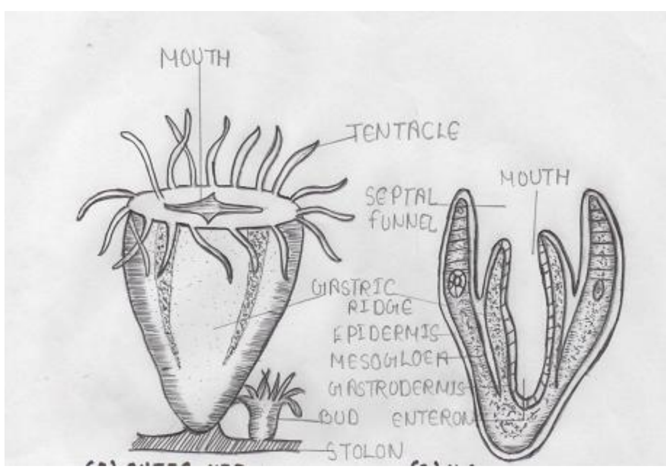
The male and female gametes are formed separately in different medusae of *Aurelia aurita.* Spermatozoa, swimming about in water, reach the ova and fertilize them either in stomach of female or in the frills of oral arms (Fig.20) thus, fertilization is either external or internal.

Formation of Planula larva:

- Frills of oral arms serve as temporary brooding of members.
- Here, each fertilized egg or zygote undergoes early development into a ciliated larval stage, called planula.
- The zygote undergoes holoblastic and equal segmentation to produce a solid ball-like morula. Soon it is transformed into a single –layered blastula, enclosing a central fluid-filled cavity or blastocoel.
- Two-layered gastrula develops by invagination, having an outer ectoderm and an inner endoderm lining an enteron cavity, with its blastopore or gastral mouth not completely closed.
- Thus, it differs from the gastrula of Hydrozoa (e.g. Obelia) which develops by a process of delamination and multipolar ingression of cells into blastocoel having no blastopore.
- The embryo now elongates, its outer cells become ciliated, blastopore closes and the typical planula larva is formed.
- At this stage, masses of planula are visible as minute patches on the oral arms of female individual.

Development of planula into Scyphistoma:

The ciliated planula eventually escapes and, after a short free-swimming existence, attaches itself to a stone or seaweed by its brood anterior, aboral end.



(A) Outer view (B)V.S Throughinter-Radius

Fig.17 Scyuphistoma Larva of Aurelia

Cilia are lost and a mouth opens at its free distal end where blastopore had closed. The larva now becomes elongated and metamorphosed into a small trumpet-shaped or hydra-like polyp, about

5mm high. Its proximal part is narrowed into a stalk-like organ, attached to the substratum by an adhesive basal disc.Tentacles bud out around the mouth. First four tentacles are perradial, subsequent four inter-radials and then 8 adradial in position. Thus, 16 long and slender tentacles are formed. Mouth becomes square in outline and its edges become elongated to form a short manubrium. The larva now looks like a trumpet-shaped polyp or Hydra, and is called hydratuba or young scyphistoma (Gr.Skyphos- cup + Stoma- mouth.Endoderm of its enteric cavity is raised into four interradial longitudinal gastric ridges or **taenioles,** characteristic of Scyphozoa, which divides the enteric cavity into four perradial **diverticula or pouches.** Simultaneously, the ectoderm between mouth and tentacles also becomes invaginated as four interradial funnel-like depressions, known as septal funnels or infundibula, which sink into 4 gastric ridges. Scyphistoma feeds and grows up to 12 mm in height and may survive in this stage for several months.

Formation of Ephyra (Strobilation):-

In autumn and winter, scyphistoma undergoes a remarkable process of budding or transverse fission of oral end, called strobilation. Distally, body develops a series of ring–like transverse constrictions or furrows which gradually deepens so that the organism resembles a pile of minute saucers or discs placed one above the other. At this stage, scyphistoma with a segmented body is called a strobili and each of the segments is called an ephyra larva. The ephyra are connected together by muscular strands. As they grow older, their muscular strands contract violently and break at intervals. So one by one the distal ephyra are pinched off from the parent strobili, which turn over, and swim away as little medusa or jelly-fish.

About a dozen ephyra are formed in a single strobilation. When food is plentiful and temperature is low, several ephyra are produced in one time (Poly disc strobilation).When food is scarce and temperature is high, a single ephyra is produced at a time (Mono disc strobilation).When all ephyra get detached, the base unsegmented part of scyphistoma grows new tentacles and continues to live as a polyp or hydratuba. It may live for several years, feeding, growing and by budding in summers,but producing ephyra by strobilation in winters.Under ecceptional circumstances the whole schiphistoma may be metamorphosed into a single adult Aurelia,without forming ephyra.

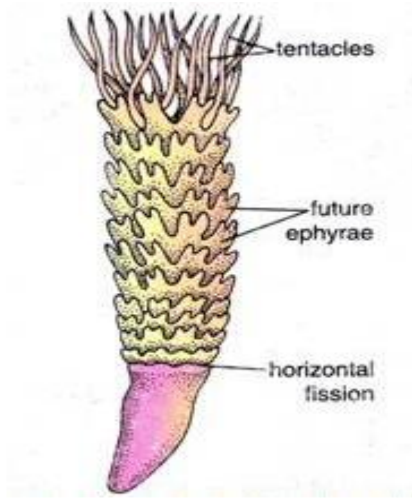


Fig.4.18 Aurelia: A Strobila

Ephyra:

A newly released ephyra is a microscopic gelatinous creature, about 1mm in diameter and with a well-developed tetramerous symmetry. The edge of its umbrella is greatly fluted, being produced into eight bifid-lobes or arms (4 per and 4 interradial), separated by 8 deep adradial Indentations or clefts. Distal extremity of each lobe in deeply notched to form a pair of primary lappets. Notch or groove between lappets is a sensory recess or niche bearing a short tentacle, which becomes tentaculocyst or rhopalium.Ephyra, contains a small segment of stomach of scyphistoma with gastric ridges.Ephyra swim actively in sea water feeding on minute organisms, such as protozoans, which are caught by lappets and transferred to mouth.

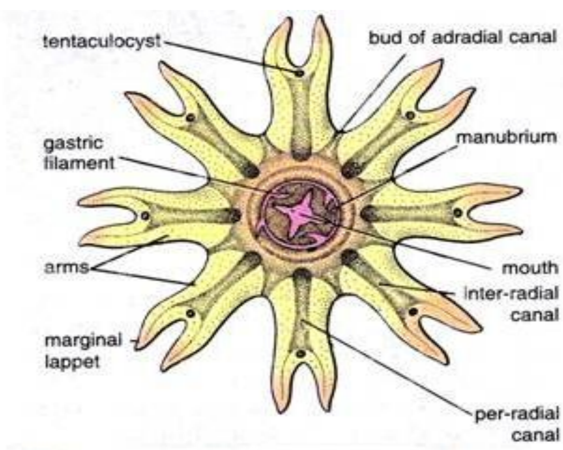


Fig.4.19 Aurelia: A free Ephyra

Metamorphosis:

As growth proceeds, mesogloea increases enormously, so that two layers of endoderm (gastrodermis) fuse to form a solid gastro-dermal lamella, except in regions of gastro vascular canals. Adradial regions grow more rapidly, gradually filling up their wide clefts, so that the umbrella of eight rayed ephyra become circular and saucer-shaped, as in an adult medusae. With the appearance of 4 oral arms and numerous marginal tentacles, ephyra is finally transformed into adult Aurelia.An ephyra formed in winter becomes a sexually reproducing adult medusa by spring or summer.

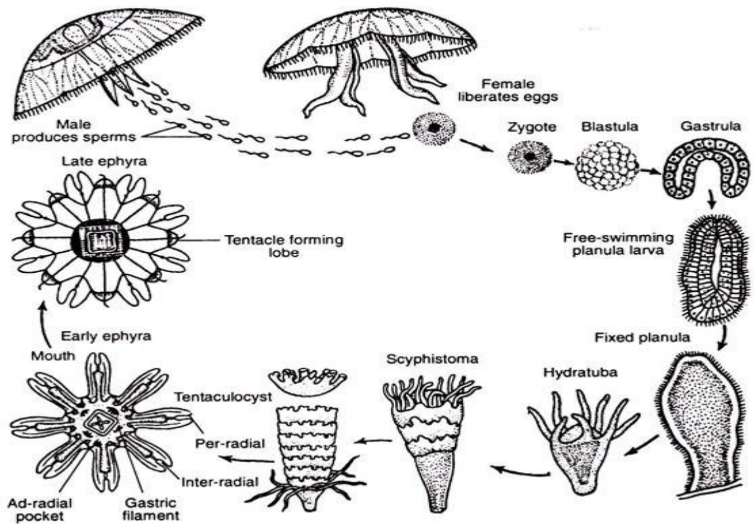


Fig.4.20 Different stages of development in Aurelia

The stages in the life history of Aurelia (Fig.4.20) are:-

Male and Female medusae⟶ gametes⟶ zygotes ⟶ ciliated planula larvae

↓

Adult Male and Female⟵medusae⟵ephyra ⟵scyphistomae ⟵hydratubae

Alternation of Generation:

Life history of Aurelia exhibits the phenomenon of “alternation of generation” since the sexual medusoid form always alternates with the asexual polypoid from.The fee-swimming adults Aurelia (medusoid form) represents sexual generation and reproduces by the formation of gamates.The fertilized ovum develops into a fixed polypoid scyphistoma through a free swimming planula larva. The polypoid scyphistoma represents asexual generation and reproduces asexual by budding.

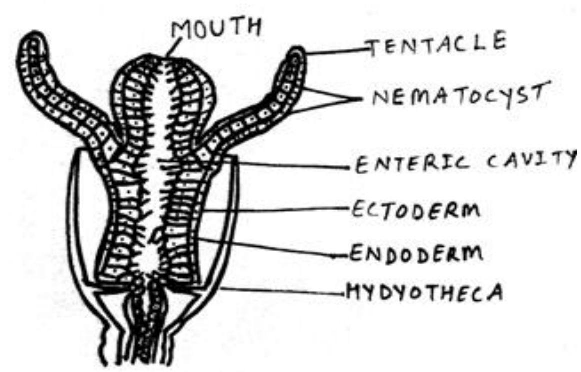
4.4.3- Polymorphism:-

Meaning of polymorphism:

Occurrence in the same species of more than one type of individuals, which differ in form and function, is known as polymorphism (Gr., Polyps- many or several + Morphe- form). This ensures an efficient division of labor between the several individuals.

Two basic forms:

In hydrozoa (or coelenterates), which may be single or colonial, there occur two main types of individuals or zooids-polyps and medusa.



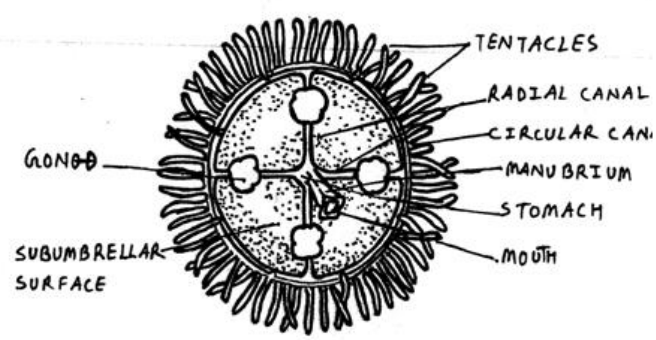


Fig. 4.21 Obelia :V.S of Polyp Fig.4.22 Medusa in Oral View

Patterns of polymorphism:

Degree of polymorphism varies greatly in different groups of Hydrozoa.

1. Dimorphic- simplest and commonest pattern of polymorphism is exhibited by many hydrozoan colonies like obelia, tubularia, etc. They have only one type of zooids (individuals).

Gastrozooids or hydranths are concerned with feeding, while gonozooids or blastostyles with asexual budding forming sexual medusa or gonophores. Such colonies, bearing only two types of individuals are called dimorphic, and the phenomenon is termed dimorphism.

2. Trimorphic- some forms, like plumularia, are trimorphic. Besides gastrozooids and gonozooids, they also possess a third type of individuals, the dactylozooids.These are functionally non-feeding and defensive polyps bearing batteries of nematocysts.

3. Polymorphic- coelenterates having more than three types of individuals are called polymorphic. Polymorphism is found in the incrusting colony of *Hydractinia* (Fig.4.27) and *Calycophoran or Siphonophora* (Fig.4.23) with five types of polyps, each performing a specialized function. These are

(i) Gastrozooids for feeding,

(ii) Spiral dactylozooids for protection,

(iii) Long sensory tentaculozooids with sensory cells,

(iv) Skeletozooids as spiny projections of chitin, and

(v) Gonozooids or reproductive individuals, bearing male or female gonophores (sporosacs) or medusa for sexual reproduction.

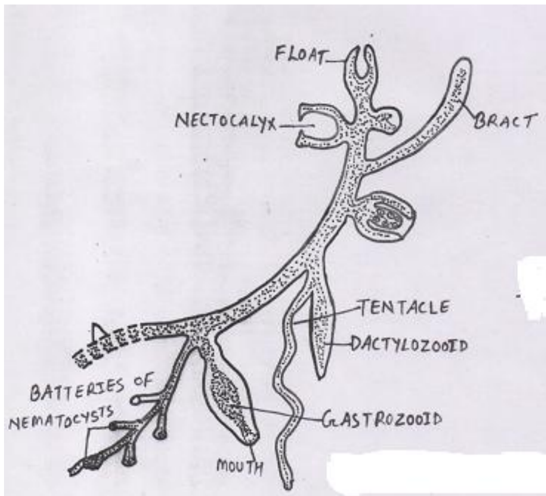


Fig.4.23 Calycophoran

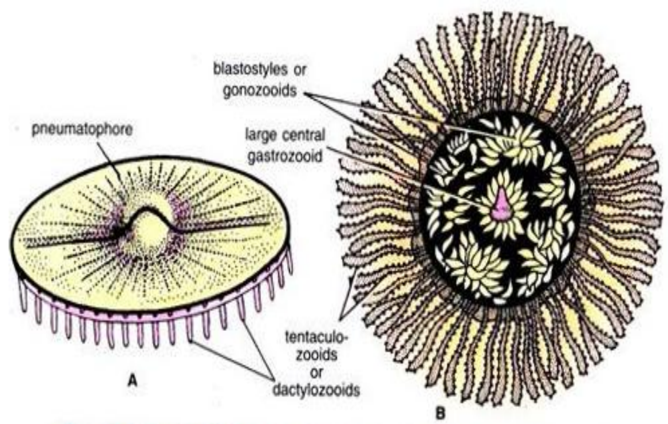


Fig.4.24 Porpita (A) Dorsal (B) Ventral

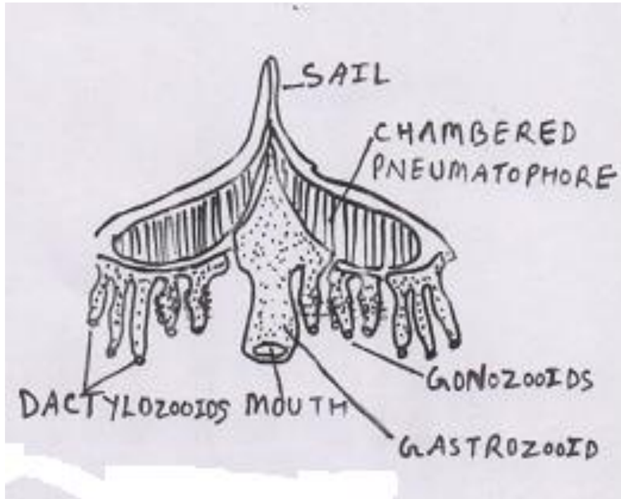


Fig.4.25 Vellella

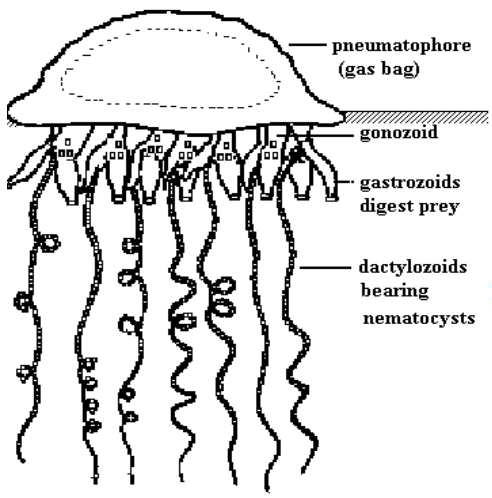


Fig.4.26 Physalia

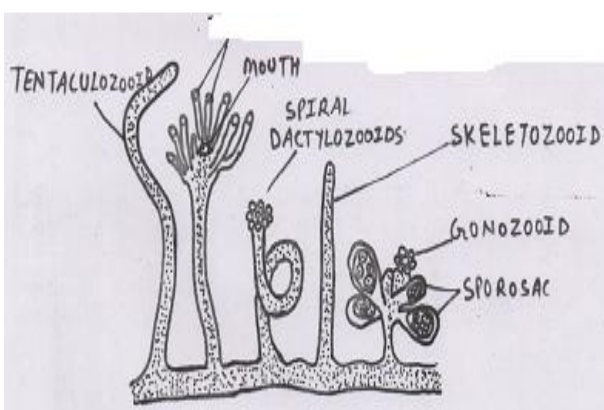


Fig.4.27 Hydractinia

Extreme examples of polymorphism are seen in the pelagic or swimming colonies of the orders siphonophora (Diphyes, Halistemmia, Stephalia, and Physalia,) and chondrophora (Porpita, and Velella,). As in Hydractinia, both polypoid and medusoid individuals, specialized for various vital functions, occur in the same colony.

Polymorphism reaches its peak in siphonophora.

(a) **Modifications of polyps-** Polypoid individuals include:

(1) Gastrozooid or feeding polyp with a mouth and a long tentacle.

(2) Dactylozooid or protective polyp without mouth and usually with a long basal tentacle.

(3) Gonozooid or reproductive polyp which produces sexual medusa or gonophores.

(b) Modifications of medusa- The medusoid individuals are of the following types:

(1) Nectophore or nectocalyxor swimming zooid with a muscular bell without manubrium or tentacles.

(2) Pneumatophore or float as a bladder-like medusa filled with secreted gas.

(3) Phyllozooid or bract, usually leaf-like and studded with nematocysts, serving for protection of other zooids.

(4) Gonophore bearing gonads, which may be either male, producing sperms, or female producing ova.

Importance of polymorphism:

Polymorphism is essentially a phenomenon of division of labour. Different functions are assigned to different individuals, rather than to parts or organs of one individual. Thus, polyps are concerned with feeding, protection and asexual reproduction, while medusas are concerned with sexual reproduction.

4.5- A brief account of coral and coral reefs and there importance:-

Corals:-

Meaning of coral

Coral animals or corals are marine, mostly colonial, polypoid coelenterates, looking like miniature sea anemones and living in a secreted skeleton of their own. Their calcareous or horny skeleton is also commonly known as coral. Some corals grow into massive, solid structures; others form large, branched colonies. Most of the corals belong to the class Anthozoa and the few to class Hydrozoa of phylum coelenterate.

Structure of coral polyp

1. Soft structure

A typical coral polyp from a colony is a small organism about 10 mm long and 1 to 3 mm in diameter. A basal disc is absent because the basal region of polyp is surrounded by a calcareous exoskeleton. Oral disc bears numerous tentacles, in several rows around an elongated, oval or circular mouth. Pharynx or stomodaeum is short and without siphonoglyphs. Mesenteries are restricted to the upper part of coelenteron and mesenterial filaments contain only one glandular lobe bearing nematocysts. Body wall is without cinclides and nematocyst bearing structures (acontia). Muscles are poorly developed while little is known about nervous system.Living polyps are found only on surface layers of coral masses. They feed at night both by raptorial and suspension feeding. When not feeding, they withdraw into cup-like cavities of skeleton.

2. Structure of coral skeleton

Skeleton of solitary coral is known as corallite. It is a calcareous exoskeleton secreted by epidermis. In a colonial coral, corallites of individual polyps fuse together to form a skeletal mass, called corallum. Each corallite is like a stony cup with a basal part or basal plate, and a cup wall or theca, enclosing the aboral portion of polyp. Cavity of cup contains a number of vertical radiating ridges called sclerosepta, proceeding from theca towards the centre of cup. Inner ends of sclerosepta are fused to form an irregular central skeletal mass or columella.

Types of corals in different groups

1. Hydrozoan corals

Order hydrocorallinaincludes few genera, like millepora, stylaster and distichopora, which are colonial and secrete massive branched calcareous exoskeletons.These are found in coral reefs with other corals. Skeleton is secreted by a modified epidermis, called calicoblastic layer. Living within the skeleton occur two types of polyps, large feeding gastrozooids and defensive dactylozooids.

2. Octocorallian corals

(a)**Order** alcyonaceaincludes marine, colonial and soft corals. A well-known genus is alcyonium, popular as “dead man’s fingers” because of its resemblance to a human hand. It has an endoskeleton of separate calcareous spicules embedded in a massive mesogloea or coenenchyme.

(b)**Order** stolonifera includes the organ pipe coral, tubipora musica, widely distributed on coral reefs in warm waters. Skeleton is made of mesogloeal calcareous spicules forming parallel and vertical tubes, each occupied by one polyp, and connected together by lateral platforms. Skeleton is dull red in colour due to presence of iron salts.

(c)**Order** coenothecalia includes a single genus heliopora, commonly known as blue coral.

Its massive calcareous, skeletonor corallium is secreted by polyps living in large, erect, cylindrical solenialtubes on the surface of skeleton.

3. Hexacorallian corals

Order madrepora includes stony corals, which are the principal builders of coral reefs. While some of them are solitary, most are colonial, assuming a great variety of forms.

(a) Solitary corals

Fungia (Fig.13), flabellum, etc., are the solitary corals or cup corals. The corallite is disc-like or mushroom shaped in form and measures 5 mm to 25 cm across.

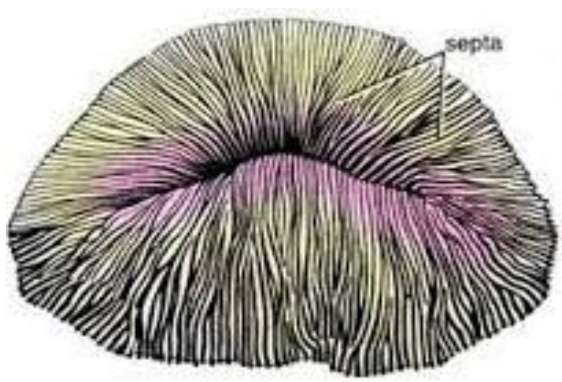


Fig.4.28 Fungia

(b) Colonial corals

Most of stony corals are colonial with plate –like, cup-like, spherical, or vase-shaped skeleton. Typical examples of colonial medreporarian corals are acropora, oculina, favia, madrepora, etc. Some of the colonies are branched.

Coral Reers

Coral colonies grow continuously in size by budding of polyps and often form extensive masses, known as coral reefs. According to T.Wayland Vaughan(1917), a coral reef is a ridge or mound of limestone, the upper surface of which is near the surface of sea and which is formed chiefly of CaCO3 secreted by coral polyps. Principal builders of coral reefs are stony corals (madreporaria), but other important contributers are the hydrocorallines and alcyonarians. Coralline algae and foraminiferan protozoa also take part in the formation of coral reefs.Reef building corals require warm shallow waters (normally above 20C). They are therefore limited to the Indo-pacific, the central western pacific, and the carabian regions north of Bermuda. About 50 species of corals contribute in the formation of reefs along the Florida Keys and in the West-Indies.

Kinds of coral reefs

The coral reefs are of three kinds, depending on how they are formed.

1. Fringing reefs

Coral reefs lying close to the shores of some volcanic islands or pert of some continent are termed fringing reefs. Fringing reefs may extend out to a distance of a quarter mile from the shore with the most active zone of the coral growth facing the sea. This seaward zone is commonly called the edge or front. A shallow water channel, 50 to 100 meters broad, lies between the reef-edge and shore at low tide, water of channel recedes at quickly exposing a flat bottom surface, called reef flat. It is largely composed of coral sand, mud dead and living coral colonies and other animals (Fig.4.29).

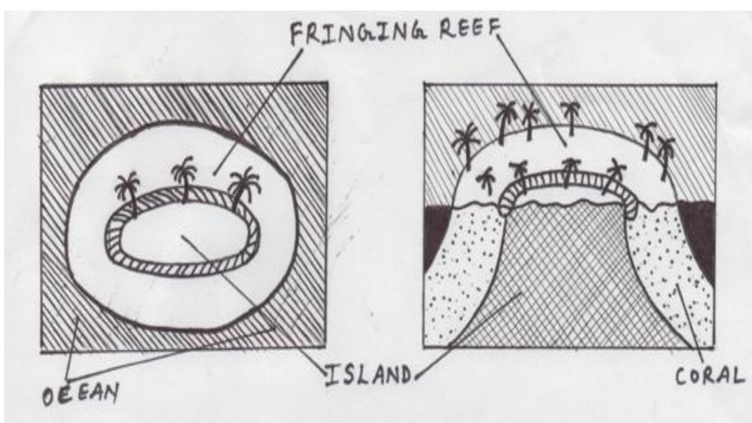


Fig.4.29 Fringing Reef

2. Barrier reefs

Barrier reefs are like fringing reefs but they are located some distance away from the shore.

The stretch of water, separating the barrier reef from land, may be half a mile to 10 miles or more in width. It is called a lagoon. It is 10 to 50 fathoms deep and suitable for navigation.

Most notable example of barrier reefs is the Great Barrier Reef along the north- eastern coast of Australia. It is about 2000 km long and upto 150 km from shore (Fig.30).

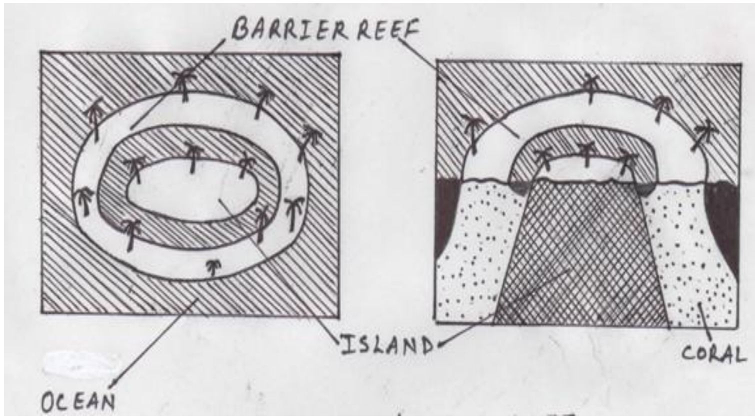


Fig.4.30 Barrier Reef

3. Atoll

An atoll is also termed a coral island or lagoon island. It is a ring-like or horse-shoe shaped reef that encircles a lagoon but not an island. The lagoon varies from a few to about 90 km across.
It may be complete or broken by a number of channels, of which only a few are navigable.
Outer side of the reef slopes off rather steeply into the depth of ocean. The atoll of Bikine, famous for atomic and hydrogen bomb tests, lies in the Pacific Ocean (Fig.4.31).

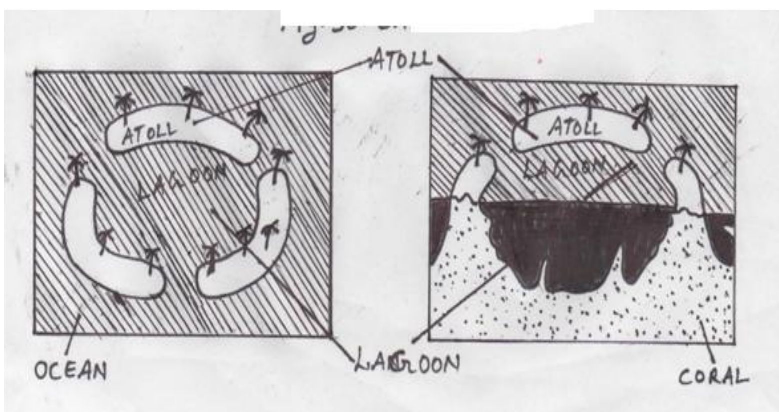


Fig.4.31 Atoll Reef

Theories of coral reefs formation

Since the reef building coral are littoral in their habitat and cannot grow below 150 feet, it is difficult to explain the great vertical thickness often attained by the coral reef. Several theories have been put forward by many scientists from time to time. A few important ones are as follows.

Darwin-Dana theory of subsidence-

During his expedition in 1931, Darwin noticed that in the region where coral reefs are found now, a sinking of land had taken place in past. He, therefore, assumed that the corals started their growth as fringing reef around the sloping shores of an island in shallow tropical sea.

By subsidence of the shore of that island they became barrier reef with a lagoon in between.

The rate of subsidence ought to have been equal to the rate of coral growth so that they have kept the surface of the reef in level with that of the ocean. The sinking island becomes smaller and smaller and finally disappeared leaving its ring –shaped contour marked in an atoll.Darwin assumed a general sinking of the entire Pacific floor which appears to be incredible. The modern concept is viewed by supposing an independent sinking of each landmass.

Submerged bank theory

According to recent scientists the corals grow to form reef on flat pre-existing surfaces during or after their submergence. This submergence is brought about by the erosion and denudation of an island both above and below water. On complete replacement of the island by a submerged plateau the builders will produce an atoll.

Daly's glacial –control theory

According to Daly's glacial –control theory, during the last glacial period the formation of ice caps lowered the ocean level by 60 to 70 meters below the present surface. Waves cut the shores to make flat platforms suitable for growth of coral. As the ice caps melted and temperature rose, corals began to grow on these platforms and rose upwards with rising ocean levels, and all type of reef were formed on the pre-existing platform. There is evidence that coral reef are growing today on submerged land and the foundation of reef are now at a much greater depth than they were when corals first began to grow.

Observation of living coral shows that their rate of growth is from 5mm to 20cm per year, thus a 50 meter deep reef could be formed in less than 8,000years and all the known reefs could have been built in less than 30,000 years. Some boring made in coral reef showed that the rested on level platform, but some other boring showed that reefs had no underlying platforms but had only sand and shell below them.

Economic importance of coral reefs:-

Corals of the remote geological past formed reef structures.They were highly favourable sites for accumulation of petroleum deposits. Thus coral reefs are of much importance to oil industry. Large quantities of corals are shipped every year for the curio trade. The coral reefs serve as habitats for many plants and animals like sponges, molluscs, echinoderms, fishes, etc. Some coral reefs are used for habitations by man as well. Some corals are highly prized for their decorative value. *Corallum rubrum* is considered to be a precious coral stone in India and china and treated as auspicious. The red coral and organ pipe coral are used in some indigenous system of medicine in India Chunks of coral skeleton belonging to species porites are used as building materials. Coral skeleton serve as raw material for the preparation of lime, mortar and cement because of their calcium carbonate and magnesium carbonate content. Coral reefs serve as good nursery grounds for commercially important fishes. Reef fish varieties are more colourful than others.

4.8- Self assessment question

1. What are corals and their importance?
2. What are the components of coral reefs?
3. What is polymorphism?
4. What are the various types of coral reefs?
5. Describe the life history of Aurelia.
6. on basis of which characters is the classification of Coelenterates based?

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4.11-Terminal Questions

1. Write short notes on:

(a) Coral reefs.

(b) Fringing reef.

(c) Barrier reef.

2. What is corallite? Discuss coral reefs, in brief?

3. Write notes on:

(a) Generalised polyp and medusa.

(b) Corallite.

(c) Types of coral reefs.

4. How are coral reefs formed?

5. Differentiate between Atoll, barrier reef and fringing reef?

6. Write the outline classification of Phylum Coelenterates?

Multiple choice questions

1. Nematocysts are found in
(a) Porifera [ ] (b) Platyhelminthes [ ] (c) Coelenterata [√] (d) Annelida [ ]

2. The function of nectocalyces in acoelenterate colony is

(a) Locomotion [√] (b) Digestion [ ] (c) Respiration [ ] (d) Reproduction [ ]

3. Bermuda is a

(a) Fringing reef [ ] (b) Coral island [√] (c) Atoll reef [ ] (d) Barrier reef [ ]

4. The exoskeleton of the colony is

(a) Corallum [√] (b) Corallite [ ] (c) Columella [ ] (d) None of these [ ]

5. Division of labour between several individuals is known as

(a) Vital activity [ ] (b) Labour division [ ] (c) Polymorphism [√] (d) Poly-functions [ ]

UNIT: 5 PHYLUM- PLATYHELMINTHES

5.1-Objectives

(1) Understanding the general characters of Platyhelminthes and classification up to the order level.

(2) Study of *Fasciola* with references to structure, reproduction and parasitic adaptations.

5.2- Introduction

The phylum Platyhelminthes was coined by Gegenbaur in 1859. It includes the simplest animals that are bilaterally symmetrical and triploblastic (composed of three fundamental cell layers). These are also known as the flatworms. Flatworms have no body cavity other than the gut and lack an anus; the same pharyngeal opening both takes in food and expels waste. Because of the lack of any other body cavity, in larger flatworms the gut is often very highly branched in order to transport food to all parts of the body. The lack of a cavity also constrains flatworms to be flat; they must respire by diffusion, and no cell can be too far from the outside, making a flattened shape necessary.

Flatworms are once divided into three groups. The free-living Turbellaria include the *planarian dugesia*, shown above; these are found in the oceans, in fresh water, and in moist terrestrial habitats, and a few are parasitic. The **Trematoda**, or flukes, are all parasitic, and have complex life cycles specialized for parasitism in animal tissues. Members of one major taxon of flukes, the Digenea -- which includes the human lung fluke which pass through a number of juvenile stages that are parasitic in one, two, or more **intermediate hosts** before reaching adulthood, at which time they parasitize a **definitive host**. The **Cestoda**, or tapeworms, are intestinal parasites in vertebrates, and they also show anatomical and life history modifications for parasitism. Platyhelminths have practically no fossil record. A few trace fossils have been reported (Alessandrello et al., 1988), and fossil trematode eggs have been found in Egyptian mummies and in the dried dung of Pleistocene ground sloth.

5.3-General Characters of Platyhelminthes

- Bilaterally symmetrical with definite polarity of anterior (head) and posterior (tail) ends

- Triploblastic, i.e., body derived from three embryonic germ layers; ectoderm, mesoderm and endoderm.
- Dorso – ventrally flattened.
- Usually with a well- defined ventral surface bearing mouth and gonophores.
- Free- living commensal or parasitic forms.
- Tissue- organ grade of organization, i.e., body cells aggregate into definite tissues and tissues make up organs.
- Body unsegmented (except in class Cestoda).
- Acoelomate, i.e., without any body cavity or true coelom.
- Spaces between various organs filled with special mesodermal tissue, the mesenchyme or parenchyma.
- Adhesive structures like hooks, spines and suckers, and adhesive secretions common in parasitic forms.
- Epidemis cellular or syncytial, frequently ciliated. Absent in some.
- Muscular system of mesodermal origin.
- Longitudinal, circular and oblique muscle layers beneath epidermis.
- Digestive system branched and incomplete without anus. Altogether absent in Acoela and Cestoda.
- Skeletal, respiratory and circulatory system are wanting.
- Excretory system includes lateral canals and proto-nephridial (flame cells). Absent in some primitive form.
- Nervous system primitive, ladder- like. Comprises a pair of anterior ganglia with longitudinal nerve cords connected by transverse nerves.
- Sense organs simple. Eye- spots or photo receptors in free living forms.
- Mostly monoecious (hermaphrodite) with complex reproductive system.
- Well- developed gonads, gonoducts and accessory organs.
- Eggs mostly devoid of yolk.
- Yolk produced separately in yolk or vitelline glands.
- Fertilization internal may be cross or self.
- Development direct or indirect.

- Usually indirect in endoparasites with a complicated life cycle involving many larvae and hosts.

5.4-Classification of Platyhelminthes

A. Class - Turbellaria (Gr., *Turbella*- a little stirring) - The class Turbellaria includes free-living freshwater planarians (E.g. Dugesia)**.**

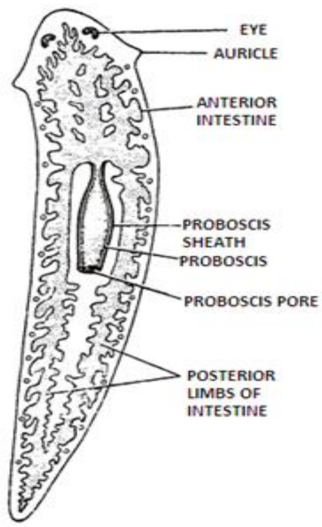


Fig.5.1 Dugesia

Same marine forms and a few parasite forms, whose beautiful colors serve as a warning of their toxicity to would-be predators, as well as the more drab freshwater planarians (Dugesia, Fig.-5.1). Some Turbellaria can swim by undulations of the body margins, but most of them glide gracefully over surfaces along a trail of mucus, pushed by **cilia** on their ventral surface.

- Usually non – parasitic, free – living worms are called planarians.
- Terrestrial marine or freshwater.
- Body unsegmented, flattened and covered with ciliated cellular or syncytial epidermis, containing mucus secreting cells and rod-shaped bodies called rhabdites.
- Mouth ventral. Intestine preceded by muscular pharynx.
- 5Suckers absent.
- Tango, chemo and photoreceptors common in free- living.
- Mostly hermaphroditic.

- Some reproduce asexually, sexual and by regeneration.
- Development usually direct.
- Life cycle simple.

Class Turbellaria divided into two orders:

1. Order - Acoela

- Minute, exclusively marine, less than 2mm.
- Ventral mouth; no muscular pharynx and without intestine.
- Flame cells, definite gonads, gonoducts and yolk gland wanting.
- Mostly free- living, found under stones, algae or on bottom mud.

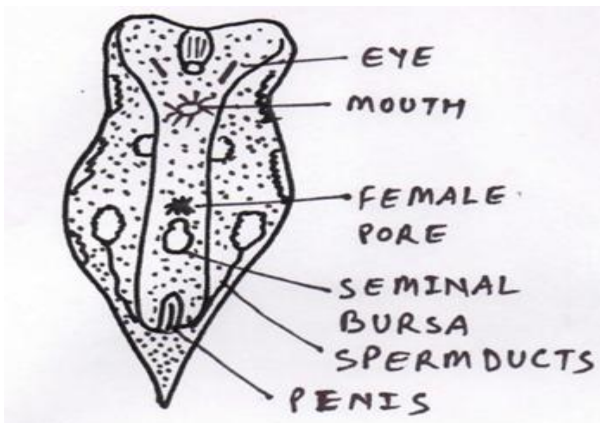


Fig.5.2 Covoluta

- Some dwell in intestine of sea- urchins and sea- cucumbers.
- Some coloured or brown by symbiotic algae.

Example: *Convoluta (Fig.5.2, 5.3), Amphiscolops, Ectocotyle, Afronta.*

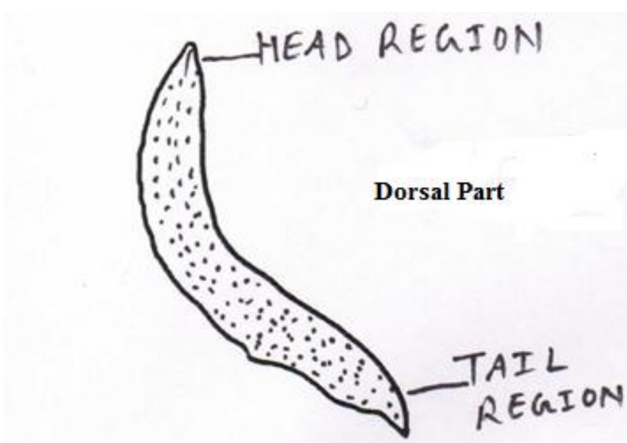


Fig.5.3 Convoluta

2. Order - Rhabdocoela

- Small, usually less than 3mm.
- Simple pharynx and sac- like intestine.
- Proto-nephridial excretory system.
- One or two gonads.
- Yolk gland present or absent.
- Marine, freshwater or terrestrial forms.
- Free- living, commensal or parasitic forms.

Order –Rhabdocoela classified into following sub-order:-

1. Suborder-Notandropora

- Exclusively fresh water forms.
- Pharynx simple.
- Testis single compact mass, penis unarmed.
- Yolk glands absent.
- Asexual fission occurs with formation of chains of zooids.

  E.g. *Catenula*

2. Suborder- Opisthandropora

- Marine or freshwater forms.
- Testis compact and penis unarmed.
- Yolk glands absent.
- Found paired nephridia.

  Eg. *Macrostomum and Microstomum*

3. Suborder- Lecithopora

- Marine or freshwater and terrestrial forms.
- Pharynx bulbose.
- Separate ovaries.
- Yolk glands present.
- Mostly free living.
- Reproduction sexual.

  E.g. Mesostoma.

4. Suborder- Temnocephalida

- Freshwater ecto-commensal forms.
- Pharynx dolii form.
- Simple gonopore.

Eg. *Temnocephala.*

3. Order -Alloecoela

- Moderate- sized, between 1and 10 mm.
- Pharynx simple, bulbous or plicate.
- Intestine straight or branched.
- Proto-nephridia paired, usually branched.
- Testes numerous.
- Penis papilla mostly present.
- Mostly marine, common in littoral sand and mud.
- Some freshwater and brakishwater forms.

Order –Alloecoela divided into four suborders.

1. Suborders- Archopora

- Marine forms.
- Pharynx plicate.
- Female reproductive organ primitive.
- Male copulatory apparatus.

Eg. Proporoplana.

2. Suborder- Lecithoepitheliata

- Marine or freshwater and terrestrial forms.
- Pharynx simple or bulbose.
- Female ducts simple
- Yolk glands absent.

Eg. Prorhynchus and Geocentrophora.

3. **Suborder- Cumulata**

- Marine or freshwater forms.
- Pharynx plicate or bulbose.

- Penis unarmed.
- Yolk glands present.

Eg- Hypotrichina.

4. **Suborder- Seriata**

- **Several** Marine forms but some freshwater forms.
- Pharynx plicate.
- Intestine usually with lateral diverticula.
- Statocyst mostly present.
- Female reproductive system consists of separate ovaries.
- Yolk glands present.

Eg. Otoplana.

4. Order - Tricladida

- This is large size turbellarians.
- Size 2 to 60 cm in length.
- Mouth mid-ventral, pharynx plicate and intestine with three branches, each with many diverticula.
- Proto-nephridia as lateral networks with many nephridiopores.
- Testes numerous, ovaries two.
- Yolk glands present
- Marine, freshwater or terrestrial forms.

Order – Tricladida divided into three suborders:-

1. **Suborder- Maricola**

- Exclusively marine forms.
- A pair of eyes.
- Typical penis papilla.
- Only sexual reproduction.

Eg. - Ectoplana.

2. Suborder- Plaudicola

- Mostly freshwater and some brackish water forms.
- Eyes two to many or some time completely absent.

- Sexual reproduction shows.

  Eg. Planaria

3. Suborder- Terricola

- Terrestrial, tropical and subtropical forms.
- Body elongated.
- Eyes more than two.
- Bursa absent.
- Asexual reproduction shows.

  Eg. Bipalium.

5. Order - Polycladida

- Moderate-sized, 2 to 20 mm.
- Pharynx plicate.
- Intestine highly branched.
- Gonads many, scattered.
- Yolk glands absent.
- Male and female gonopores separate.
- Marine, many bottom dwellers of littoral zone.

Order – Polycladida classified into two sub order:-

1. Suborder- Acotylea

- Pharynx vertical.
- Sucker absent.
- Tentacles nuchal type.
- Eyes absent.

  Eg. Notoplana.

2. Suborder- Cotylea

- Pharynx tubular
- Sucker present
- A pair of marginal tentacles bearing eyes.

  E.g. Thysanozoon (Fig.4)

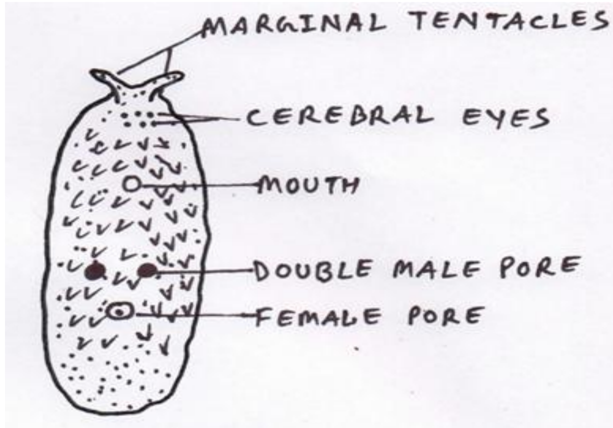


Fig.5.4 Thysanozoon

B. Class- Trematoda (Gr. *Tremta*- hole + *eidos*- form) – The class Trematoda, commonly called flukes, are unsegmented parasitic flatworms that usually parasitize a snail as an **intermediate** host (in which they reproduce asexually) and a human or other vertebrate as a **definitive** host (in which the worms mate and lay eggs). Many species have other hosts between these two, such as fish or frogs. Trematodes usually have a pair of suckers for crawling and clinging to the host's tissues. Many humans are infected with blood flukes, liver flukes, lung flukes, and other trematode parasites of great medical importance.

- 1 Ecto- or endoparasitic flatworm, called flukes.
- Body unsegmented, dorso-ventrally flattened, leaf like.
- Tegument thick but without cilia and rhabdites.
- Suckers and sometimes hooks present.
- Alimentary canal with anterior mouth, simple pharynx and two main branches.
- Three pairs of longitudinal nerve cords.
- Mostly monoecious (Hermaphrodite).
- Development direct (in ectoparasites) or indirect (in in endoparasites) with alternation of hosts.
- Life history simple or typical.
- Ovary single and testis two too many.

Class- Trematoda divided into three orders:-

1. Order - Monogenia

- Mostly ecto-parasitesim cold blooded aquatic vertebrates.

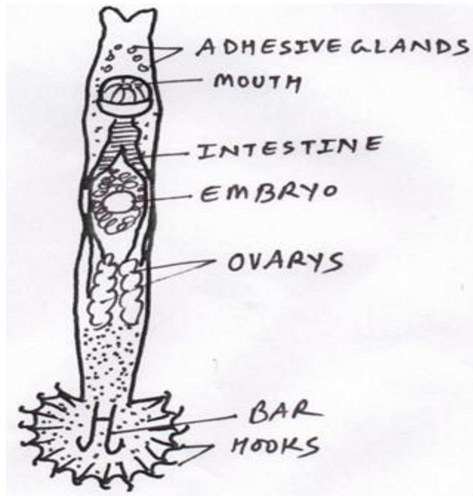


Fig.5.5 Gyrodactylus

- Posterior adhesive organ or opisthaptor with suckers armed with hooks or spines.
- Excretory pores two, situated anteriorly on dorsal side.
- Vagina one or two.
- Uterus small with a few shelled eggs.
- Only a single host in life cycle.
- Free swimming ciliated larva called onchomiracidium.
- One host in life cycle.

  E.g. Gryodactylus (Fig.5), Dactyogyrus, Polystoma, Diplozoon

2. Order - Digenea

- Mostly endoparasites in vertebrates and invertebrates.
- Two suckers, oral and acetabulam, both devoid of hooks.
- Single posterior excretory pore.
- No vagina.
- Uterus long with numerous shelled eggs.
- Life cycle complex with numerous larval stages in two to three intermediate hosts.

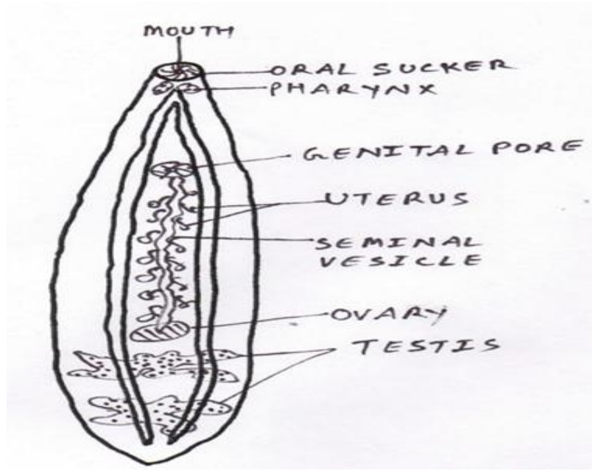


Fig.5.6 Opisthorchis Sinensis

- Larval forms reproduce asexually before metamorphosis.
- One to more intermediate hosts in life cycle.

Examples: Bucephalus, Fasciola hepatica , Fasciola gigantic, Param-phistomum, Paagonimus, Schistosoma, Opisthorchis (Clonorchis,.

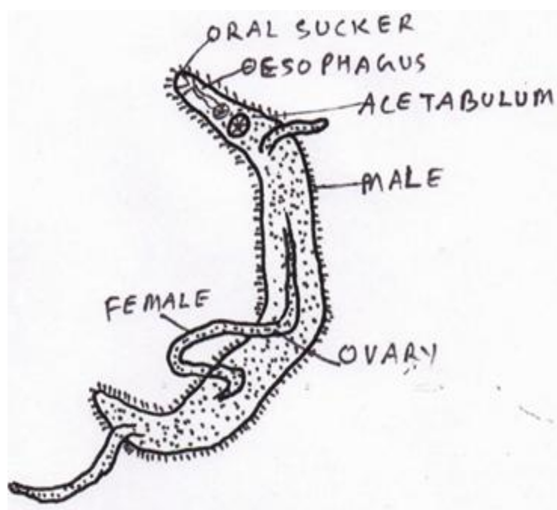
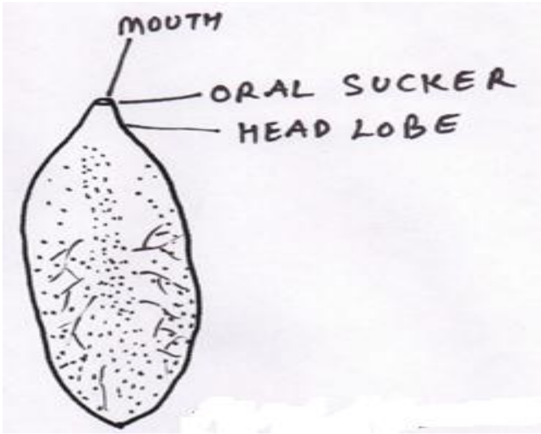


Fig.5.7 Schistosoma



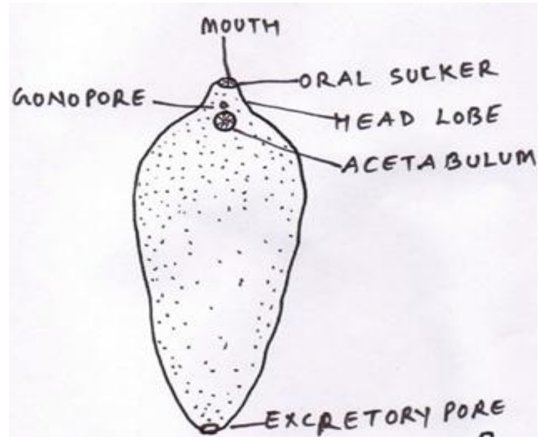


Fig.5.8 Fasciola Gigantica Fig.5.9 Fasciola Hepatica

3. Order - Aspidocotylea

- Oral sucker absent.
- Large ventral sucker subdivided into several suckers without hooks.
- Anterior end without paired adhesive structures.
- Only one testis in male system.

Fig.5.10 Aspidogaster

- Endoparasites in gut of fishes and reptiles.
- Nephridiopore single.
- Life cycle simple.

Example: Aspidogaster (Fig.10), Cotylapsis, Stichocotyle.

C. Class- Cestoda (Gr., *kestos*- girdle + *eidos*- form) - The Cestoda, commonly called tapeworms, is segmented, ribbon like parasites usually found as adults in the small intestines of vertebrate animals. Unlike the other classes, they have no digestive tract, they can absorb predigested nutrients from the host's intestine. The body consists of a long chain of segments, each with its own reproductive system. The anterior end is a knob-like holdfast called a scolex, equipped with suckers and often hooks for attachment to the host's intestine. In general, tapeworm infections are not as medically serious as trematode infections, but some tapeworms can be lethal.

- Endoparasitic flatworms, called tapeworms.
- Body segmented, elongate, flat, ribbon-like.
- Tegument with microvilli.
- Scolex (head) with suckers, or hooks, or both.
- No alimentary canal.
- No sense organs.
- Each mature segment or proglottid monoecious, with male and female organs.
- Life cycle complicated involving one or more intermediate hosts.
- Embryos with hooks.

Class- Cestoda classified into two subclasses:

A. Subclass - Cestodaria

- Body unsegmented, leaf- like, without scolex and strobila (monozoic or body undivided).
- Only one set of monoecious reproductive system.
- Larva lycophore with 10 hooks.

  Subclass – Cestodaria divided into two orders.

1. Order - Amphilinidea

- No suckers.
- Pharynx protrusible.
- Male genital pore and vegina situated posteriorly.
- Uterus coiled.
- Endoparasitic in coelom of primitive fishes.

  Example: *Amphilina*.

2. **Order- Gyrocotylidea**

- An anterior sucker and a posterior rosette- shaped adhesive organ present.
- Eversible proboscis at the anterior end.

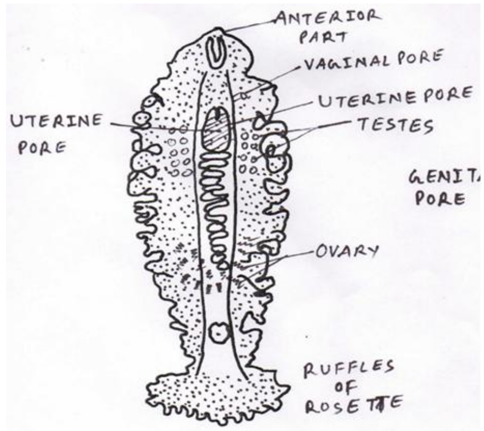


Fig.5.11 Gyrocotyle

- Endoprasites in chimaeroid fishes.

  Example: *Gyrocotyle (Fig5.11).*

B. Subclass - Eucestoda

- Body long, ribbon- like.
- Divided into scolex, neck and strobila with many proglottids (polyzoic).
- Mostly with several sets of monoecious reproductive organs.
- Larvae with six hooks.

Class- Eucestoda classified into eleven orders:-

1. Order - Proteocephalidea

- Scolex with 4cup- shaped suckers.
- Ovary bilobed.
- Utrus branched.
- Vitellaria scattered.
- Parasitic in freshwater fishes, amphibians and reptiles.

  Example: *Proteocephalus, Ophiotaenia.*

2. Order - Tetraphyllidea

- Scolex with 4 leaf - like bothria.
- Testes anterior to ovaries.

- Vitelline glands scattered.
- Parasitic in intestine of elasmobranches fishes.

  Example: *Phyllobotheium.*

3. Order - Disculicepitidea

- Scolex with large cushion- like pad at anterior end.
- Female gonopore, anterior to male gonopore.
- Testes numerous.
- Uterus lobed.
- Endoparasites of Selachii.

  Example: *Disculiceps.*

4. Order - Lacanicephaloidea

- Scolex divided by a transverse groove.
- Upper disc- like lower with 4 suckers.
- Vitellaria as two lateral bands.
- Intestinal parasites in elasmobranch fishes.

  Example: *Lecanicephalum, Tetragonocephalum.*

5. Order - Pseudophyllidea

- Scolex with 2 to 6 bothridia.
- Testes numerous.
- Ovary bilobed.
- Vitellaria follicular.
- Parasitic in freshwater fisher (teleosts).

  Example: *Dibothriocephalus, Haplobothrium.*

6. Order - Trypanorhyncha

- Scolex with 2 to 4 bothria and 4 spiny tentacles.
- Vitellaria in continuous layer in cortical parenchyma.
- Parasitic in elasmobranch fishes.

  Example: *Tetrachynchus.*

7. Order - Cyclophyllidea (=Taenioidea)

- Scolex with 4 large deep suckers and hooks.

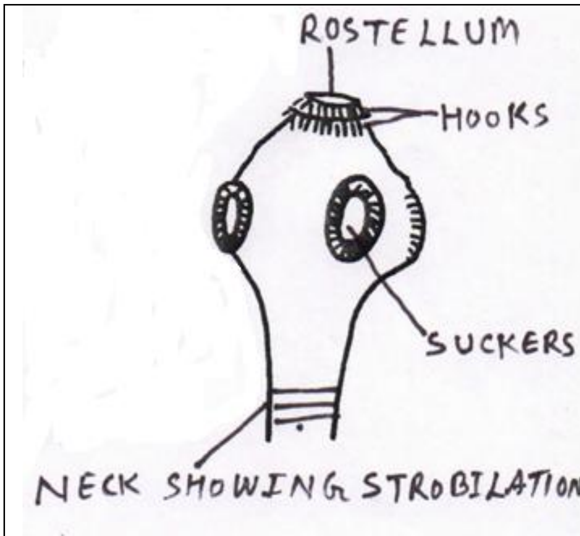


Fig.5.12 Head Region

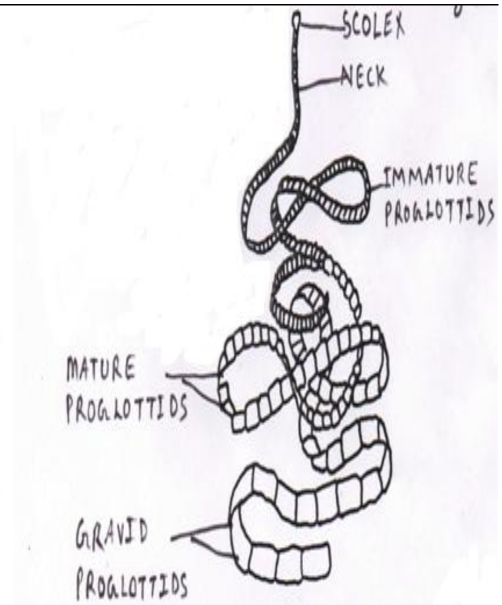


Fig 5.13 Teania Solium

- Ovary lobed.
- Uterus blind.
- Vitellaria follicular.
- Parasitic in amphibians, reptiles, birds and mammals.

  Example- *Taenia (Fig.13, 14), Moniezia, Echinococcus (Fig.14), Dipylidium, Hymenolepsis.*

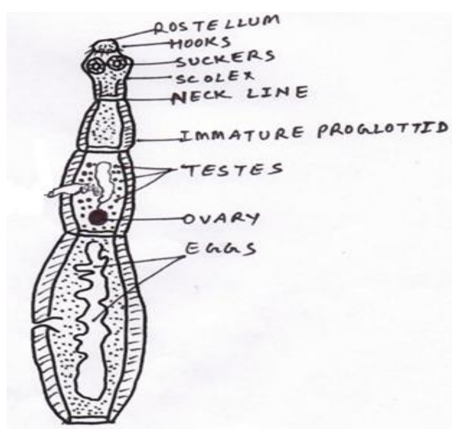


Fig.5.14 Echinococcus Granulosus

8. Order - Aphoridea

- Scolex with 4 suckers.
- Rostellum armed.

- No external segmentation.
- Ootype absent.
- Vitallaria absent or present.
- Sex ducts and genital apertures absent.
- Parasites in freshwater fishes of Japan.

  Example: *Nematoparataenia, Gastrotaenia.*

9. Order - Nippotaeniidea

- No scolex but well- developed erminal sucker.
- Proglottids few.
- Vitellaria few.
- Parasites in freshwater fishes of Japan.

  Example: *Nippotaenia, Amurotaenia.*

10. Order - Caryophyllidea

- Scolex without ture suckers or bothria.
- Eggs non- embryonated when laid.
- Parasites in fishes.

  Example: *Caryophyllaeus, Archigetes, Glaridacris*.

5.5- Study of *Fasciola*

Fasciola hepatica is a common liver fluke. Main species of Fasciola like *Fasciola hepatica* (Liver fluke- Sheep) and *Fasciola gigantica* (Liver fluke – Cattal) (Fig.15).

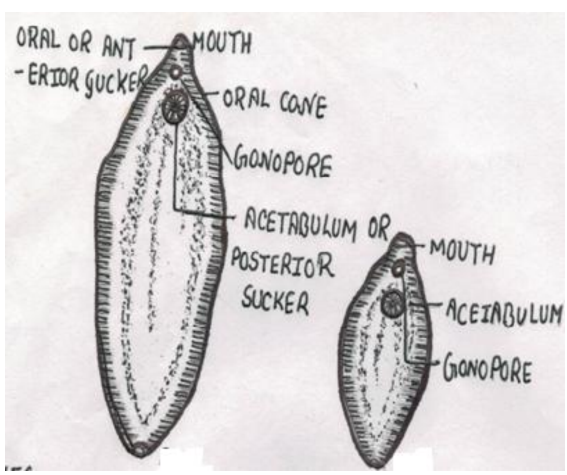


Fig.5.15 Liver Fluke: (A) Fasciola Gigantica (B) Fasciola Hepatica

Systematic Position:

PHYLUM - ASCHELMINTHES
CLASS - TREMATODA
ORDER - DIGENIA
GENUS - FASCIOLA
species - hepatica

Habit and habitat:

- *Fasciola hepatica* is a digenetic trematode.
- It is endo-parasite in the bill passage and liver of sheep and cattle and completes part of its life cycle in snail.
- It enjoys world-wide distribution.
- Its primary host is sheep and secondary host is freshwater snail.

External morphology:

Shape: Body is soft and fleshly. It is dorso-ventrally flattened and leaf like, somewhat oval in appearance.

Its anterior end is broad and rounded while posterior end is narrower and bluntly rounded.

Size: It is about 18-30mm long and 4-15mm broad.

Colour: The colour is slightly pinkish and the margins appear to be brownish or blackish. Internal organs are roughly visible because of transparent body wall.

5.5.1-Structure of *Fasciola Hepatica:*

- Head lobe or cephalic cone.
- The broad anterior end of body is produced into a conical projection.
- The head lobe or oral cone, cephalic cone.
- It bears mouth at its tip.

Suckers:

There are two suckers-

1. Anterior or oral sucker is cup-shaped and muscular.
   - It surrounds mouth. Its muscles rediate from the margin of mouth to the periphery.
   - Oral sucker is a suctorial organ. It helps in ingestion as well as in adhesion.

2. Posterior or ventral sucker is saucer-shaped.
   - It lies about 3-4mm from oral sucker mid ventrally.
   - It is without an aperture and is also known as acetabulum.
   - It is meant for attachment only.

Apertures:

- Mouth is terminal, situated on rhe tip of oral cone and is surroundd by oral sucker.
- Commmon gential Aperture or gonopore lies midventrally a little in front of acetabulum.
- A single excretory pore is situated midventrally at the posterior end.
- Opening of Laurer's canal appear temporarily during breeding season, a little anterior to the middle of body on the dorsal side.

5.5.2-Reproduction (Life cycle of Fasciola hepatica):-

Copulation:-

- Although *Fasciola i*s a hermphodite animal but cross fertilization occurs.
- The two flukes copulate inside the bile duct of host's body.
- The cirrus of one is inscrted into the opening of Laurer's canal of the other organism and the sperm along with the parasitic fluid make their way into the Laurer's canal, from where these move to the oviduct.
- Fertilization may also occur. Sperm enters the uterus of fluke through female gential aperture.

Fertilization:-

- The eggs are fertilized in the uterus or in ootype.
- The fertilize eggs are deposited with yolk cells produced by vitelline gland and are encircled by chitious shell or egg capsule.
- A single fluke may produce about 2, 00,000 eggs in about 11 years and 30,000 eggs per year.

Eggs:-

- The fully formed fertilized capsulated eggs are inside the uterus.
- The first cleavage is complete but unequal and produced (i) a small geanular propagatory cell and (ii) a large somatic or ectoderm of larva.

- The propagatory cell further divided into two types of cells propagative cells and somatic cells. The somatic cells after division from larval body structure.
- The propagatory cells form the germ cells. Within 9-15 days, the embroyinc development is complete and a ciliated marcidium larva is formed.

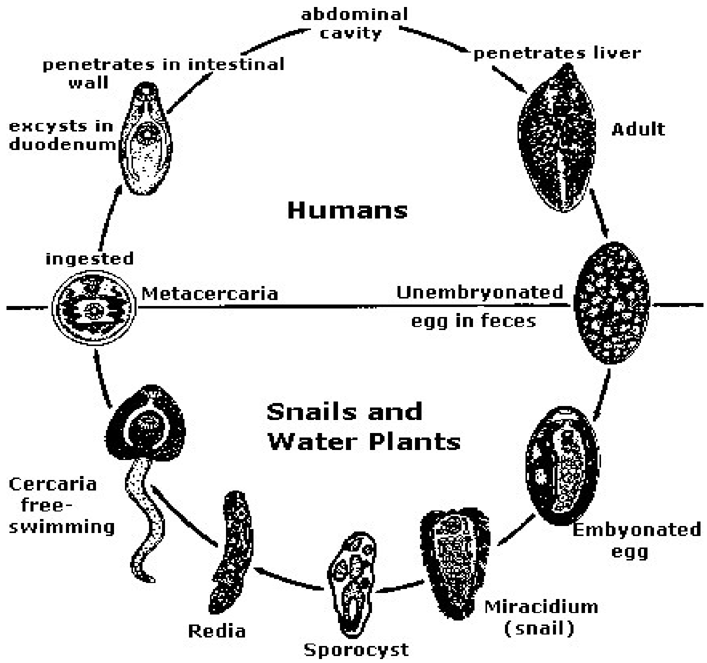


Fig.5.16 Life cycle of Fasciola Hepatica

Segmentation and early development:-

- Segmentation and cleavage start even when the eggs are inside the uterus.
- The first cleavage is complete but unequal and produces (i) a small granular propagatory cell and (ii) a large somatic or ecto-dermal cell.
- Repeated division of the somatic cell further from ectoderm of larva.
- The propagatory cell further divides into two types of cell- propagative cells and somatic cells.
- The somatic cells after division form larval body structures.
- The propagatory cells form the grem cells. Within 9-15 days, the embryonic development is complete and a ciliated miracidium larva is formed.

Hatching:-

- Further development occurs only when capsule reaches water or moist area.

- In contact with water, the operculum of egg capsule opens and ciliated marcidium larva hatches out. It swims in water actively.

Larval stage of Fasciola hepatica:-

Miracidium larva- It is the first larval stage in the life cycle of *Fasciola hepatica.*

It swims actively in water in search of secondary host, the snail of genus, Limnaea.

External Structure:-

- Miracidium of Fasciola is about 0.07mm long, oval or conical. Its broad anterior end is apical lobe or apical papilla or terebratorium.
- It bears opening of (i) a pouch like multinucleated apical gland and (ii) a number of unicellular penetration gland.

Miracidium larva:-

Miracidium larva does not feed. It swims actively in search of its secondary host.

In case it fails to reach the host, it dies within 24 hours. If it finds the snail, it penetrates through snail's soft skin or respiratory tissue dissolving larval secretion of penetration glands makes a minute opening in the host tissue.

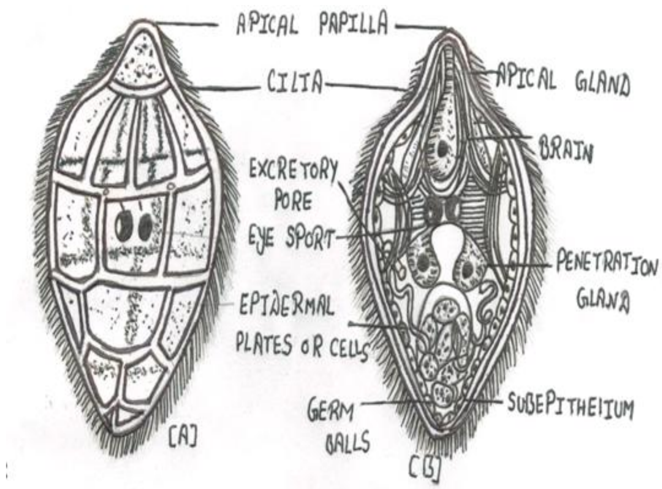


Fig.5.17 Miracidium Larva of Fasciola (A)External structure(B) Internal structure

Inside the host tissue, miracidium throws off ciliated epidermis, penetrates deeper to reach the lymph vessels or pulmonary chamber. Here it changes into second larval stage, the sporocyst larva.

Sporocyst larva:-

- Miracidium lose its apical gland, penetrated gland, brain, eyespot and change into a sac-like sporocyst larva.

- It looks like an elongated sac about 0.7mm long.
- Their body walls retain all the layers of miracidium's body wall except the ciliated epithelium.
- It consists of a thin cuticle, a layer of circular and longitudinal muscles.
- The wide interior is occupied by the protonephridia and germ cells. Each protonephridium now consist of two flame cells.
- These open on the surface by a common pore. A rudimentary gut is also found.

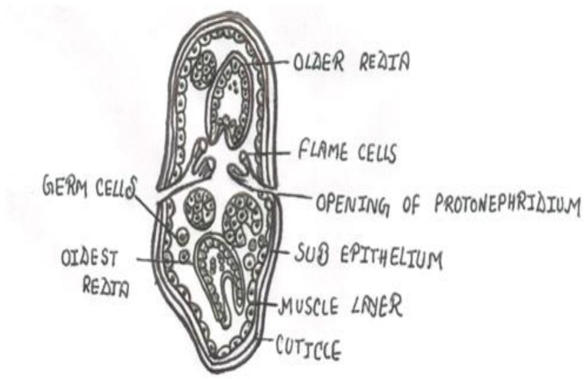


Fig.5.18 F.Hepatica:-Sporocyst larva of Fasciola

The germ cells undergo repeated division to produce redia larvae, but may also produce daughter sporocysts. A single sporocyst may contain 5-18 redia.

Redia larva:-

- It is an elongated and cylindrical sac.
- It comes out by the rapture of sporocyst.

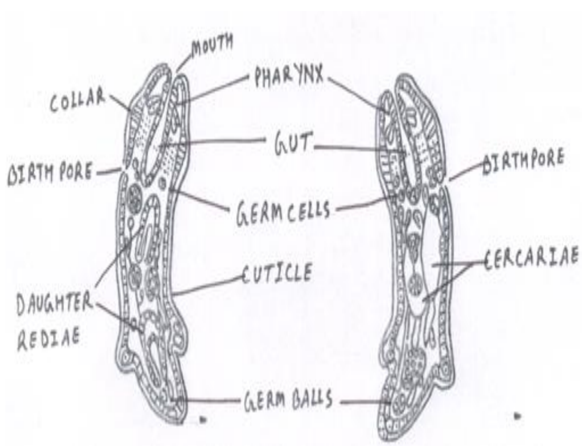


Fig.5.19 Redia Larva of Fasciola

It is covered with a thin cuticle secreted by sub epithelium. At the anterior end a small mouth, a muscular suctorial pharynx with unicellular pharyngeal glands and small gut. Slightly posterior to the pharynx, the anterior end is surrounded by a muscular band like collar and just behind it is the birthpore. A pair of conical projection, the procruscular or lappets is present at the posterior end. The interior of the body is filled with loose parenchyma, through which are found groups of germ cells called germ balls and highly branched flame cells. Their excretory ducts open through the paired excretory pore. The germ balls present inside redia give rise to generation of daughter rediae in summer months and produced cercaria Larvae in autumn.

Cercaria larva:-

A fully formed cercaria larva possesses a flattened heart-shaped body with a long contractile tail. Its body surface covered with thin cuticle with backwardly directed spines. The anterior end bears mouth, muscular pharynx, oeso-phagus and bifid intestine. The mouth is surrounded by oral sucker. A vebtral sucker or acetabulum is also present between the two limbs of the intestine.There are numerous flame cells. A small excretory duct arise from the bladder and opens to the exterior by excretory pore situated at the base of the tail. A number of unicellular cystogenous glands are situated below the large body wall.

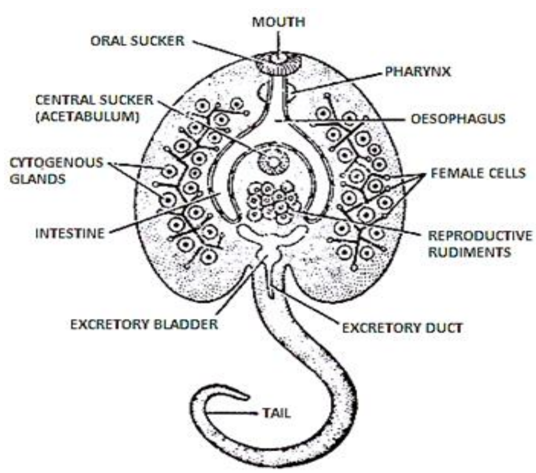


Fig.5.20 Cercaria Larva of Fasciola

Their secretion forms the cyst around the larva when it is converted into metacercaria. Groups of germ cells are also present.When mature the cercaria leaves the redia through birthpore it also wriggles out of the snail body. It swims in water for some time and finally settles down on the blade of some aquatic weed. It sheds off the tail and a cyst is formed by the secretion of cystogenous gland. Thus a metacercaria is formed.

Metacercaria:

The metacercaria is somewhat rounded with thick outer covering of cuticle in the from of cyst. The Cystogrenous cells of the cercaria disappear and the flame cells increase in number.

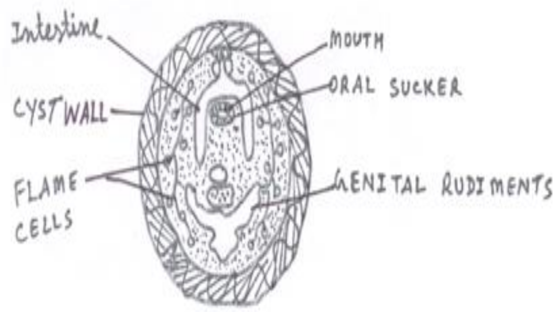


Fig.5.21 Metacercaria Larva of Fasciola

Infection to the final host:

The metacercaria enters the final host, the sheep, when it grazes on the aquatic weeds and reaches the intestine. In the intestine the cyst is dissolved by the action of digestive enzymes and young fluke comes out. It reaches the liver through the hepatic portal system and starts its existence inside the bile passage.

Infection:-

- The vertebrate host (sheep, goat, etc.) gets the infection by grazing on grass, leaves and other vegetation to which metacercaria cysts are attached.
- The invertebrate host (snail) acquires infection when a miracidium, at random, established contact with a suitable part of its body (Fig.5.22).

Pathogenesis or Symptoms:

- Infection of invertebrate host (snail) result in a partial or complete destruction of the affected site, which is preferably the digestive gland (liver) or gonad.
- In case of heavy infection, snail considerably increases in size.
- Of significant economic important is the effect of *F. hepatica* on its vertebrate, host whose bile ducts as well as liver may be damaged.

- In bile ducts, it causes inflammation and hepatits, resulting in loss of its epithelium and thickening of wall, followed by calcification and formation of gall stones.
- Heavy infection upset the normal metabolism of liver. This due to haemorrhage caused and irritation inflicted by cuticular spines. The disease thus cused is called liver-rot or fascioliasis. Symptoms of liver-rot are more acute in lambs than in sheep, appear about a month after infection.
- Frequently, death may soon result due to cerebral apoplexy. However, if the host survives few weeks of infection, it falls a victim to acute anaemia and falls even at mild contact.

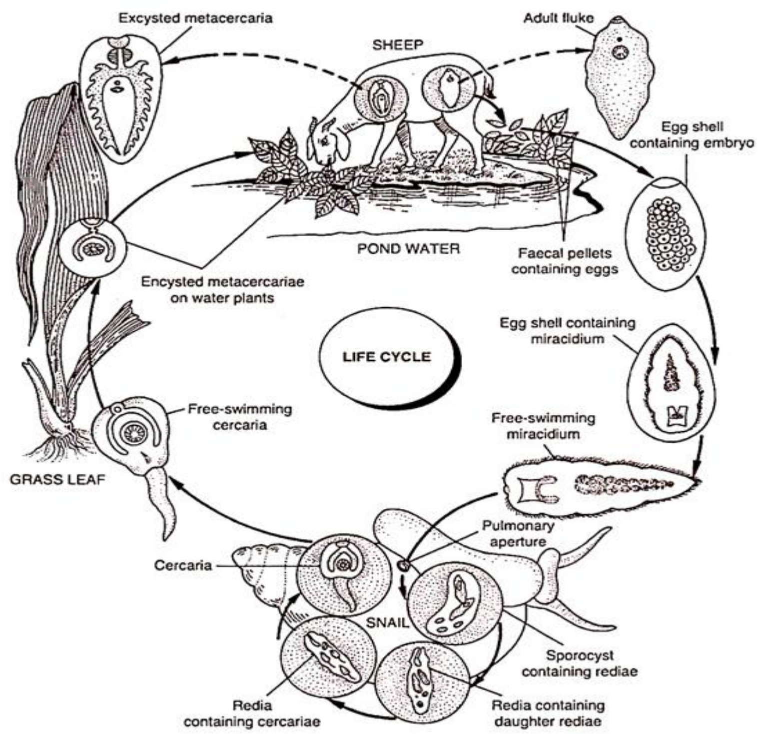


Fig.22 Life cycle of F.Hepatica

- Its appetite declines, rumination (chewing the cud) becomes irregular and at times there is fever and increase in respiratory activity.
- Conjunctiva becomes whitish-yellow, and dry and brittle wool falls off. After three months of infection comes the fatal period.

- Large oedemas or swelling (‘’watery poke’’) appear on jaws. Lactation and breeding are greatly reduced.
- Rarely does the host survive this period. In case it does, the fluke may migrate to the duodenum and finally escape to the outside world with faces.
- When this happens, or when fluke somehow dies in situ, the host recovers considerably.
- Infection by *F. hepatica* takes a huge toll of sheep annually.
- In England it caused the death of about one and a half million sheep in 1830 and about double in number in 1879-80.
- Ireland lost 60 percent of its flocks in 1882.

Therapy or treatment:

- Treatment of infection is not easy because it is difficult to introduce drugs in bile passages of infected sheep.
- Anti-helminth drugs such as hexachloroethane, carbon tetrachloride, filcin, emetine hydrochloride, phenothiazine and tetrachlorothane are being employed or treating case of liver-rot.
- These drugs are fairly effective in killing stages of the parasite in liver.

Prophylaxis or Prevention:

It is better to prevent infection by control of the vector or intermediate host. Preventive measures include:-

- Killing heavily infected sheep.
- Destroying eggs and manure of infected sheep.
- Feeding infected sheep with salt and little dry food.
- Killing or checking snail population.
- Snail is killed by adding copper sulphate solution in ponds and ditches or by draining their pastures as they are unable to survive long dry periods.
- Ducks feed on snails and can be usually employed in removing their population. Breeding of snails can be avoiding infection by consuming thoroughly washed and adequately cooked vegetables.

5.5.3-Parasitic Adaptation of Fasciola:-

- Liver fluke has undergone great modification, morphologically as well as physiologically, to suit its existence as an end parasite in the bile ducts of sheep.
- Outer tegument is thick, permeable to water, but enzyme-resistant, so that parasite is not digested by digestive juices of the host.
- Locomotary organs are absent as not required by adult. However, free swimming larvae, such as marcidium have cilia and cercaria has a locomotary tail.
- Oral sucker, acetabulum and spines of body wall of adult worm serve as organs of attachment in the host's body.
- Alimentary canal is without anus as there is no undigested food for egestion.
- Suctorial phyranx helps in sucking bile etc. and much branched intestine serves to distribute digested food to all parts of the body.
- Adult lacks circulatory, respiratory and sensory organs as they are not needed.
- Nervous system is poorly developed for the same reason. However, free swimming miracidia has sensory eye sport.
- Respiration is anaerobic as free O2 is not available.
- Reproductive system is highly developed.
- Number of eggs produced is enormous (about 200,000 eggs per fluke). This is necessary to offset several hazards resulting in great mortality.
- Resistant egg shells around zygote provided further safety from unfavorable environmental condition.
- Hermaphroditism ensures self-fertilization even in the absence of another companion for copulation. It is necessary of the species.

Liver rot:-

When sheep are infected by the liver fluke Fasciola hepatica, the liver sheep is seriously affected in structure and function. This disease is known as ''Liver rot'', or "Fascioliasis'.

5.7 - Self assessment question

1. Write the summary of the life history of *Fasciola hepatica*?
2. Write the important parasitic adaptations of *Fasciola*?
3. What is the mode of respiration in *Fasciola hepatica*?
4. How does excretion take place in *Fasciola hepatica*?

5. Explain the structure of the body wall in *Fasciola.* Draw and mention some adaptive features.

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5.9 - Terminal Questions

1. Give an account of the life history of *Fasciola hepatica*.
2. What are adaptations? Explain with reference to the structure of Fasciola *hepatica*...
3. Where is Fasciola *hepatica occurence? Give an account of its structure.*
4. Describe reproductive organ of *Fasciola hepatioca*? (Only diagrammatic).
5. Describe the various larval form s of *Fasciola hepatioca.*
6. What do you understand by alternation of generation or digenetic life cycle?
7. What is the infective stage of Fasciola for sheep?
8. Where Fasciola found /
9. Which organism is the secondary host of fasciola?
10. To which larva does miracidium larva give rise to?
11. What is miracidium?
12. What are flame cells?
13. Where can you locate flame cells?
14. Enumerate, in brief, the parasitic adaptations of Fasciola hepatica?

Multiple choice questions:-

1. Liver fluke belongs to class

(a) Cestoda [ ] (b) Nematoda [ ] (c) Termatoda [√] (d) Turbellaria [ ]

2. Fasciola hepatica is found in

(a) Intestine of Sheep [ ] (b) Stomach of Sheep [ ] (c) Liver of sheep [√] (d) None of them [ ]

3. Fasciola hepatica is

(a) Free living [ ] (b) Ectoparasite [ ] (c) Endoparasite [√] (d) Ecto and endoparasite [ ]

4. Which of the following infects the snail in life cycle of Fasciola?

(a) Cercaria [ ] (b) Miracidium [√] (c) Redia [ ] (d) Metacercaria [ ]

5. Which of the following stage in the life cycle of Fasciola is infective stage for sheep?

(a) Cercaria [ ] (b) Miracidium [ ] (c) Redia [ ] (d) Metacercaria. [√]

6. The intermediate host in the case of liver fluke of is

(a) Snail [√] (b) Man [ ] (c) Pig [ ] (d) Fly [ ]

1. The correct sequence of various larvae in liver fluke is

(a) Miracidium, sporocyst, redia, cercaria, metacercaria [√]

(b) Miracidium, sporocyst, cercaria, metacercaria, redia [ ]

(c) Cercaria, sporocyst, redia, miracidium, metacercaria [ ]

(d) Sporocyst, redia, miracidium, cercaria [ ]

2. Larva of Fasciola hepatica that bores into snail is

(a) Cercaria [ ] (b) Hexacanth [ ] (c) Miracidium [√] (d) Redia [ ]

UNIT: 06 PHYLUM- ASCAHELMINTHES

6.1-Objective:-

(1) Understanding the general characters of Ascahelminthes and classification up to the order level.

(2). Study of *Ascaris lumbricoides* with references to structure, reproduction and parasitic adaptations.

6.2-Introduction:-

There are several groups of animals in which the space inside the body is a pseudocoel. It is not a true coelom because it is not lined with mesodermal epithelium, and represents a persistent embryonic blastocoel. These groups of animals are known as pseudocoelomates (presence of a cavity, the pseudocoel, between the gut and body wall), and they are often placed within a single super phylum aschelminthes. Gegenbaur (1859) created a group nemathelminthis to place some pseudocoelomates animal. The name aschelminthes was proposed by grobben (1910), in place of the older name nemathelminthes. It has been derived from two Greek words: askes - cavity + helmins – worm.

6.3- GENERAL CHARACTERS AND CLASSIFICATION:-

6.3.1-GENERAL CHARACTERS:-

- Mostly aquatic, free living or parasitic.
- Usually small, even microscopic. Some reach a meter or more in length.
- Body slender, vermiform, unsegmented, flator cylindrical, bilaterally symmetrical and triploblastic.
- Organ system grade of body organization.
- Head not distinctily formed with well-defined sense organs.
- Body wall with a syncytial or cellular epidermis externally covered with thick cuticle of scleroprotein.
- Cilia absent except anterior cilia of rotifers.
- Musculature includes mostly longitudinal fibres.
- Body cavity pseudocoel not lined by mesoderm.

- Digestive canal complete with mouth, specialized pharynx, straight non-muscular intestine and posterior or anus.
- No circulatory and respiratory systems.
- Excretory system is of protonephridia and canals.
- Cloaca is present in some species.
- Nervous system of cerebral ganglia, or of circumenteric nerve ring with anterior and posterior nerves.
- Mostly dioecious. Male usually smaller then female.
- Gonads and ducts single or double.
- Eggs with chitinous shell. Cleavage is determinate and spiral.
- Development usually direct with no larval stages, or indirect with a complicated life history.

6.3.2-CLASSIFICATION OR MAJOR GROUPS:-

Aschelminthis includes one very large group (nematoda) and four smaller groups (rotifera, gastrotricha, kinorhyncha and nematomorpha). According to some zoologists such as l.h.hyman (1951), aschelminthis is regarded as a distinct phylum, and the various groups included in it as classes. However, others treat different groups as separate phyla and the name of aschelminthis as a superphylum or without any taxonomic rank. Modified classification was proposed by storer and usinger (1971).

Such an approach has been followed in the following in the scheme of classification.

1. class-rotifera

(gr., rota - wheel + ferre - to bear)

- Microscopic animals found in ponds, lakes and streams, rarely in oceans.
- Body wall thickened into stiff plates or lorica into which head may retreat.
- Anterior end with ciliary disc or corona (wheel organ), used for feeding and locomotion.
- Post –anal tail or with two toes and adhesive glands for attachment.
- Body musculature includes longitudinal and transverse muscle bands and strands.
- Digestive system with a grinding organ, mastax, lined internally by strong cuticle.

- Excretory system of proto-nephridia and two proto-nephridial tubes which empty into a bladder.
- Nervous system of three major ganglia and nerves.
- Sensory organs antennae and eye spots.
- Males smaller than females.
- Parthenogenesis common.
- No larval stage.

  Examples: philodina, asplanchna, rotaria, epiphanes (=hydatina).

Class rotifera divided into following three orders.

A). order- monogonontea

- Males small in size.
- Male showed degenerate nature.
- One testis found in male.

  Eg. Mytilina.

b). order- bdelloidea

- Swimming or creeping forms.
- Male showed degenerate.
- Pedal glands more than two.

  Eg. Rotifera and philodina.

c). order- seisonacea

- body elongated
- Gonads found in the paired form.

  Eg. Seison.

2. class- gastrotricha (gr., gaster- stomach + trichos- hair)

- Microscopic, marine and fresh water.
- Body wall with cuticle bearing short, covered, dorsal spines.
- Corona absent cilia on ventral surface for locomotion.
- Posterior end forked and with adhesive tubes and glands for attachment.
- Body musculature includes six pairs of longitudinal muscles.
- Mouth surrounded by bristles.

- Pharynx tri-radiate and muscular.
- Excretory system with two proto-nephridia.
- Nervous system with a saddle –shaped ganglion and two lateral nerves.
- Dioecious or monoecious.
- Fresh water females parthenogenetic.
- Development direct.
- Young and adult alike.

Class gastrotricha divided into following two orders:-

a). order- chaetonotoidea

- Fresh water forms seen.
- One paired proto-nephridia found.
- Reproduction by parthenogenesis.

  Eg. Chaetonotus.

b). order- macrodasyoidea

- Marine worm like.
- Proto-nephridia absent.
- Parthenogenesis type reproduction seen.

  Eg. Macrodasys

3. CLASS - Kinorhyncha (=Echinodera) (Gr., kineo- to move + rhynchos- beak)

- Marine, microscopic worm like animals.
- Superficial segmentation of body into 13 or 14 overlapping rings.
- Body surface with spiny cuticle but no cilia.
- Mouth cone or head protrusible and covered with scalids.
- A pair of adhesive tubes in front part of the ventral surface.
- Pseudocoel with fluid containing anoebocytes.
- A nerve ring with ventral cord with a ganglion in each zonite.
- Eyespots in some.
- Digestive system complete, with salivary glands.
- Dioecious gonads as a pair of tubular sacs.
- Penial spicules in males.

- Fertilization internal.
- Metamorphosis with several larval stages.

Class kinorhyncha divided into following two orders:-

a). order-homalorhagida

- Head and neck both.

  Eg. Trachydemus.

b). order- cyclorhagida

- Only head ring is protrusible.

  E.g. *Echinoderes.*

4. CLASS- Nematomorpha (Gr,.Nema- thread + Morphae- shape)

- Hair worms, found in fresh water. One genus marine.
- Body long, slender and cylindrical.
- Cuticle thick bearing small papaillae. Epidermis cellular, single layered.
- Digestive system complete in larva but degenerates in non-feeding adults. Cloaca present.
- Pseudocoel mostly filled with parenchyma.
- No circulatory, respiratory and excretory systems.
- Nervous system with a circumentric nerve ring and a mid ventral nerve cord.
- Dioecious, gonads and gonoducts paired. Oviducts also open into cloaca.
- Juveniles parasitic in grasshoppers, crickets and other insects.

Class nematomorpha divided into following two orders:-

A). Order- Cordioidea

- Swimming bristles are wanting.
- Gonads paired.

  Eg. Paragordius

B). Order- Nectonematoidea

- Marine forms.
- Swimming bristles are arranged in two rows.
- One gonad found.

  Eg. Nectonema.

5. CLASS- Nematoda (Gr., Nema-thread + Eidos- form)

- Aquatic, terrestrial or parasitic roundworms.
- Body elongated, cylindrical and unsegmented.
- Body wall with thick cuticle, cellular or syncytial epidermis and longitudinal muscule cells in four bands.
- No cilia, circulatory and respiratory systems.
- Digestive system complete with muscular pharynx and glands.
- Excretory system of glandular organs, canals or both.
- Nervous system with circumenteric ring and anterior and posterior nerves.
- Sense organs simple.
- Dioecious. Male with penial spicules and smaller them female.
- Gonads one or two. Male gential ducts lead into cloaca, female genital duct with a separate opening.
- Fertilization internal. Development usually direct.
- No asexual reproduction or regeneration.

Class nematoda divided into following eighteen orders.

a).order- enploidea

- Cuticle not ringed.
- 10-12 bristal in one or two circlets.
- Anterior end with 6 labial papillae.

  Eg. Enoplus

b). order-dorylaimoidea

- Cuticle smooth with bristles.
- Rear part of pharynax enlarged.

  Eg. Dorylaimius

c). order-mermithoidea

- Head sense organs reduced to papillae, generally 6.
- Amphids cyathiform or reduced.
- Pharynx long and blind.
- Intestine also blind.

Eg. Mermis.

d). order-chromadoroidea

- Aquatic nematodes with smooth or ringed cuticle.
- Pharynx with a posterior bulb.
- amphid sprial

Eg. Paracytholaimus.

e). order-araeolaimoidea

- Cuticle smooth rarely with bristles.
- Labial papillae present.

Eg. Plectus.

f). order-monhysteroidea

- Cuticle smooth or slightly ringed.
- anterior end with 4, 6-8 bristles

Eg. Cylindrolaimus

g). order-desmoscalecoidea

- Marine nematodes.
- Cuticle heavily ringed.
- Anterior end with 4 bristles.

Eg. Tricoma.

h). order-rhabditoidea

- Free living or parasitic nematodes.
- Pharynx with posterior bulb.
- Caudal glands absent.

Eg. Rhabditis

i). order-rhabdiasoidea

- Smooth nematodes without definite pharyngeal bulb.
- Hermaphrodite nature and sometimes parthenogenesis also occurs.

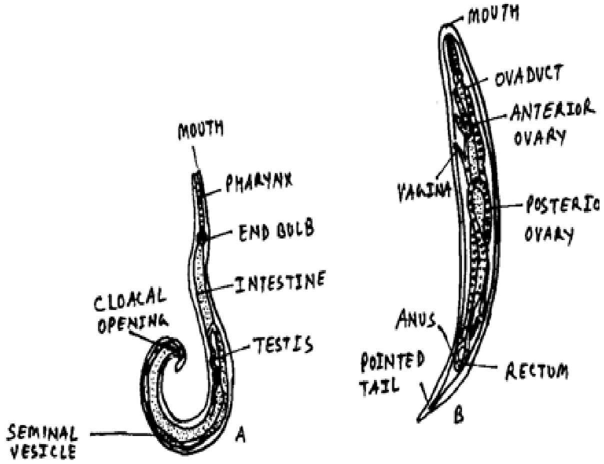
Eg. Rhabdias

j). order-oxyuroidea

- Pharynx with a posterior bulb.

- Females with a long pointed tail.
- Male with one or two equal spicules.

  Eg. Enterobius (fig.4a and 4b)



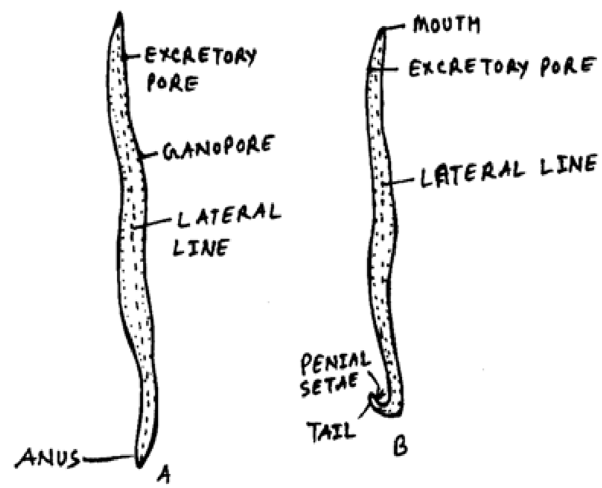


Fig.6.1: Enterobius Vermicularis: (A) Male (B) Female Fig.6.2: Ascaris lumbricoides: (A) Female (B) Male

k) order-ascaroidea

- Mouth surrounded by three prominent lips.
- Pharynx without posterior bulb.
- Buccal capsule absent.
- Tail of female blunt.

  Eg. Ascaris

l). order-strongyloidea

- Mouth without conspicuous lips.
- Pharynx without bulb.
- Males with copulatory bursa, Eg. Ancylostoma.

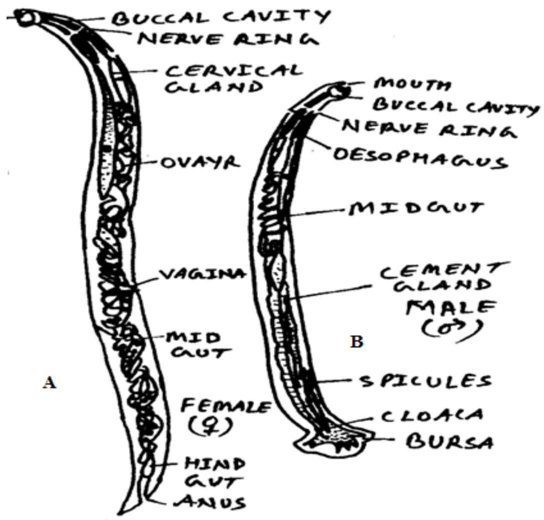


Fig.6.3 (A) Ancyclostoma Duodenal (Female)
(B) Ancyclostoma Duodenal (Male)

m**).** order-spiruroidea

- Mouth with two lateral lips.
- Pharynx without bulb.
- Males with bursa.

Eg. Rictularia

n). order-dracunculoidea

- without definite lips
- Pharynx as in spiruroidea.
- Vulva usually not functional.

Eg. Dracunculus.

o). order-filarioidea

- Lips absent in filiform worms.
- Buccal capsule small.
- Vulva anterior in female.

Eg. Wuchereria (fig.4).

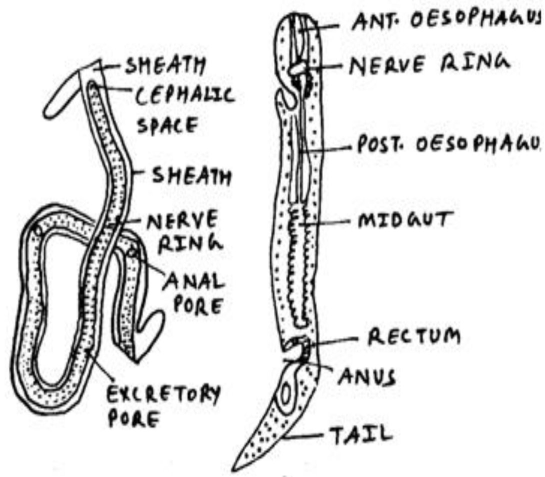


Fig 6.4 Wuchereria Larva

p). order-trichinelloidea

- Mouth without lips.
- Pharynx slender.
- Body filiform anteriorly.

  Eg. Trichinella

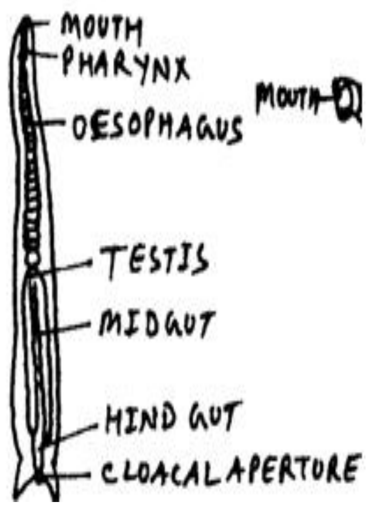


Fig.6.5 (A) Trichenella Spiralis (Male)

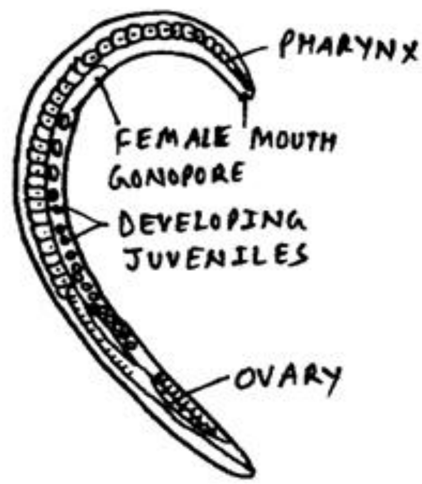


Fig.6.6 (B) Trichenella Spiralis (Female)

q). order-dioctophymoidea

- Mouth without lips surrounded by 6-12 papillae.
- Males with muscular brusa.

Eg. Dictyophyme**.**

6.4 Study of Ascaris:-

6.4.1-Structure:-

Life history of *Ascaris lumbricoides*

Systematic Position

PHYLUM ASCHELMINTHES
CLASS NEMATODA
ORDER ASCAROIDEA
GENUS *ASCARIS*
Species *lumbricoide*

Habit and Habitat:-

- *Ascaris lumbricoides* commonly known as round worm.
- *Ascaris* is largest nematode parasite in the human intestine.
- It is cosmopolitan nematode parasite.
- A billion people are estimated to be infected with roundworm.
- The adult worms live in a small intestine of infected persons.
- It is found more commonly in children than in adults.
- As many as 800 to 1500 adult worms may inhabit a single host.

External Features:-

Shape:-

- Body is elongated, cylindrical and vermiform.
- It is a large size nematode showing sexual dimorphism.
- Sexes are separate.
- The female is larger than the male**.**

Size:-

- The female length measures 20-40 cm in length and 6-8 mm to width.
- The male is 15-30 cm long and 2-4 cm wide.

Coloration:-

- Fresh specimens are pale pink or flesh coloured become white outside the body.

Morphology:-

Anterior End:-

- The anterior end of the body bears a terminal triangular opening, the mouth **(Fig.6C, 6D and 6E)**.
- It is bounded by three rounded rasping lips; one of them is mid–dorsal and two are ventro –lateral or sub–ventral.
- The mid dorsal lip is broadly elliptical with central forked and fleshy core.
- It is beset with a circle of four minute sensory papillae.

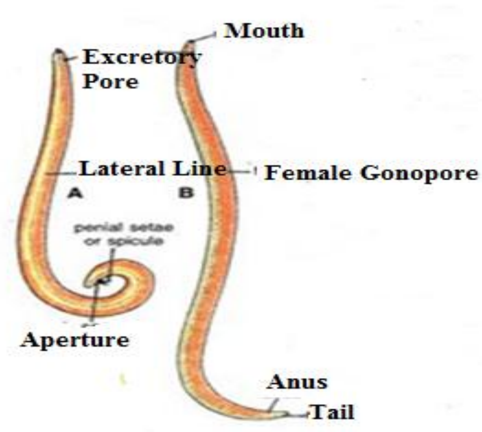


Fig.6.6 Ascaris lumbricoides, Adult worm in lateral (A) Male (B) Female

- The two latero-ventrals are also provided with forked fleshy cores and bear two rows of sensors papillae each with two papillae.
- These are also provided with special sensory structures, the amphids.
- The sensory papillae are tango receptors and the amphids are chemo-receptors.
- The inner edges of the lips are finely toothed.
- Slightly behind the anterior end and situated mid ventrally is a small excretory pore.
- In female the gonopore is situated at about anterior 1/3rd of the body.

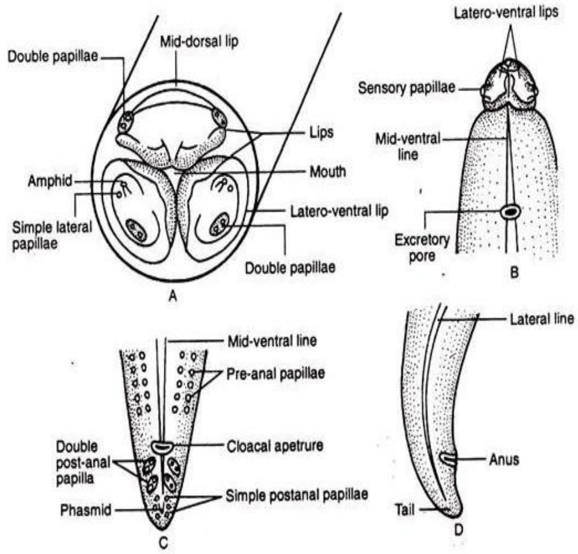


Fig.6.7 Ascaris lumbricoides: (a) face view of mouth & lips (b)Anterior end of ventral view (c) Posterior end of female in side view (d)Posterior end of male in ventral view

Posterior End:-

- The posterior part of the body exhibits sexual dimorphism.
- It is straight in male and sharply curved in female.
- It bears anus as a transverse slit in female and a cloacal opening in male.
- Two spicules or penial setae sometimes project out from a cloacal opening.
- The part of the body behind the anus or cloacal opening is known as tail.
- In male, it carries 50 pairs of pre-anal and 5 pairs of post-anal papillae.

Body wall:-

The body wall is formed of following three layers:-

1. Cuticle 2. Epidermis 3. Muscle layer

1. Cuticle- It is a thick, tough, wrinkled and transparent outer most layer of the body wall.

- It is continuous with the cuticular lining of the pharynx and rectum.
- The cuticle is not chitin.
- It is soluble in KOH.

2. Epidermis-

- Below the cuticle is a syncytial epidermis with many nuclei but no cell walls. The number of epidermal cells is small.
- Fat and glycogen reserves are abundantly found in the epidermis.

3. Muscle layer-

- Internal to epidermis and lying between the epidermal chords is the body wall musculature consisting exclusively of a single layer of longitudinal fibres running along the length of the body.

Body Cavity:-

The space between the body wall and alimentary canal is not a coelom but a pseudocoel. It is formed by the breakdown of connective tissue cell. Pseudocoel has fibrous tissue and fixed cells called coelomocytes or giant cells. Pseudocoel is filled with a clear, protein-rich fluid, the pseudocoelomic fluid which distributes digested food and transports various metabolites.

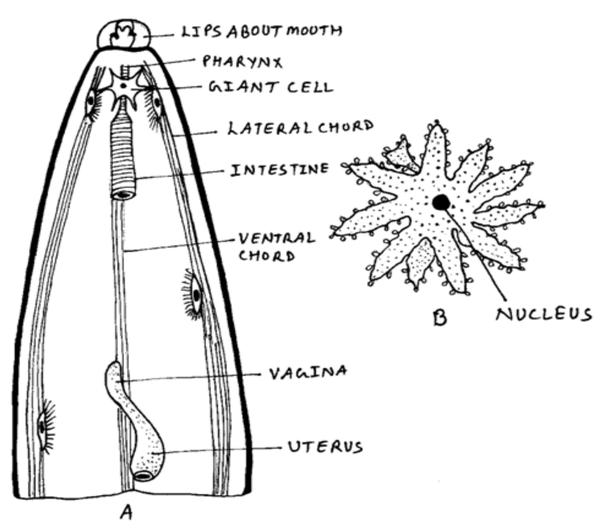


Fig.6.7 Ascaris lumbricoides (A) Position of giant cell (Pseudocoelomocytes) in pseudocoel. (B) Single pseudocoelomocytes Enlarged

Digestive System

The digestive system is very simple consisting of a) mouth b) esophagus or pharynx c) intestine d) rectum **(Fig.8A, B, C and D)**.

a). Mouth- The mouth is a tri-radiate aperture situated at the anterior tip surrounded by three lips or labia.

b). Pharynx-

- The pharynx is a small cylindrical chamber with thick and muscular walls formed of radially arranged muscules.
- Its cavity has a tri-radiate appearance and is lined by cuticle.
- In the pharyngeal wall are embedded two palmately branched subventral oesophageal glands and a pinnately branched dorsal oesophageal glands.

c). Intestine –

- It is a long, thin walled, dorsoventrally flattened tube which is devoid of muscles.
- The intestinal wall is formed of a single layer of elongated columnar cells lined externally by a basement membrane and a thin layer of cuticle.
- The free inner margin of each cell is produced into several fingers–like projections, the microvilli (Kessel et.al., 1961).
- They form sort of tightly packed brush borders which increase the surface area.

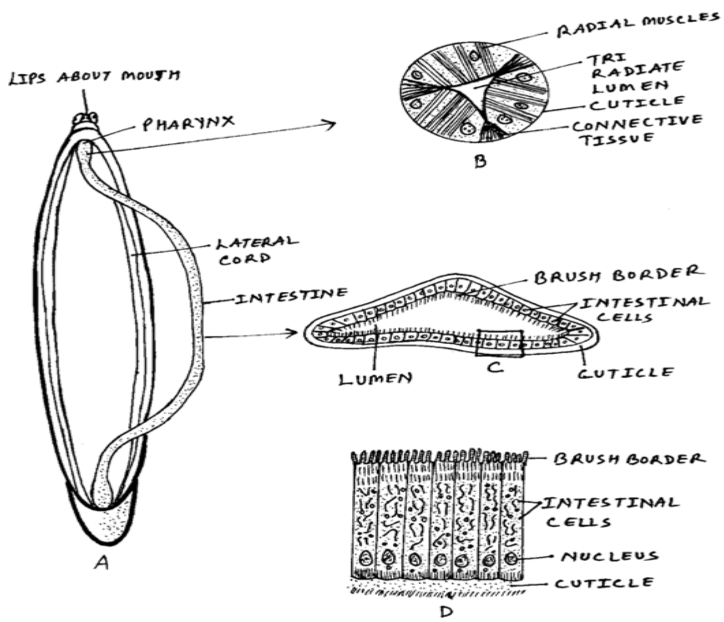


Fig.6.8 Ascaris: (a) Alimentary canal (b) Pharynx in T.S (c) T.S of Intestine (d) a portion of Intestinal wall showing brush border

d) Rectum-

- It is the distal narrow part of the intestine having comparatively thick walls.
- The wall of the rectum consists of tall columnar cells and is lined externally by the muscle layer and internally by cuticle.
- In male, rectum opens into the cloaca which also receives the ejaculatory duct.
- In female, it opens to the exterior by a transverse slit-like anus.
- In the rectum are larger unicellular rectal glands, 3 in the female and 6 in the male.

Respiratory System:-

- There are no respiratory organs in *Ascaris*.
- The parasites carry on anaerobic respiration as the oxygen content in the intestine of host is very poor.
- It obtains energy by the breaking down of glycogen into Co_2 and fatty acids which are excreted though the cuticle like those of flatworm parasites, eg. *Fasciola.*

Excretory System:-

- In marine nematodes, the excretory system consists of one or two large renette gland cells lying ventrally in the pseudocoel near the junction of the pharynx and intestine.
- The excretory system is in the shape of H.
- It consists of two longitudinal canals running one in each lateral line.
- The two canals are connected anteriorly by a transverse canal in the form of network and open on the ventral side by a single excretory pore.
- The excretory system has no internal opening, cilia, flame cells or nephridia.
- The nitrogenous waste chiefly comprises urea which diffuses into the pseudocoelomic fluid.
- The excretory canal are said to secrete this urea which is eliminated through excretory pore.
- Some ammonia and urea are also passed out along with the faecal matters.
- Ascaris excretes more urea when water is scarce.

Nervous System:-

- The nervous system of Ascaris is well developed and complicated.

- The nervous system is hypodermal and consists of a circumpharyngeal ring or nerve ring and nerves originating from it.
- The circumpharyngeal nerve around the pharynx consists of a number of cephalic ganglia. These are:

(a) Six papillary ganglia

b). Two ventral ganglia

c). Two sub-dorsal ganglia

d). Two dorsal ganglia

Nerves:-

- Six nerves are issued anteriorly from the nerve ring to the various sense organs of the anterior part of the body.
- Eight nerves arise posteriorly from the nerve ring. These are

a). A dorsal nerve

b). A ventral nerve

c). Paired dorsal-ventral nerves

d). Paired ventro-lateral nerves

e). Paired lateral nerves

Of these the dorsal and ventral nerves run through the dorsal and ventral lines upto the posterior part of the body.

Sense Organs

- Due to parasitic mode of life, Ascaris has developed sense organs which are very simple.
- The only sense organs are the sensory labial papillae and amphids present on the oral lips.

6.4.2-Reproductive System:-

- In Ascaris, like other nematodes, sexes are separate, i.e., dioecious.
- Sexual dimorphism found in Ascaris.
- The male is smaller in size than the female; its tail is curved, while females' tail is straight.
- It bears cloaca and a pair of spicules or penial setae but female possesses anus and spicules absent, male possesses pre-anal and post-anal papillae which are absent in female.
- The male system is reduced to a single tube but the female system is double.

Male Reproductive Organs

The male reproductive organs are-

a). Testis-

- Testis is monorchic, i.e., single in Ascaris but it may be diorchic, i.e., two testis in some nematodes.
- The testis of Ascaris is a long, thread-like and coiled tube.
- Cytoplasmic rachises are developing sperms.

b). Vas deferens-:-

- The testis continues distally into a short and thick coiled tube of the same diameter, the vas deferens.
- It is very short and leads into the seminal vesicle.

c). Seminal vesicle:-

- The seminal vesicle is a wide tube present in the posterior 1/3rd part of the body.
- It joins the ejaculatory duct.

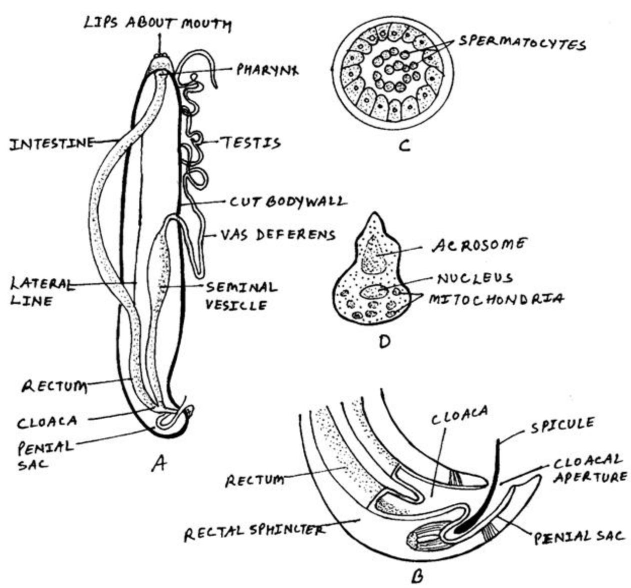


Fig.6.9 Ascaris lumbricoides (a) Male Reproductive system

(b)Posteror end of male Ascaris (c) T.S of vas deferens (d) a male sperm

d)Ejaculatory duct-

- The **seminal** vesicle narrows at its posterior end to form a short, but muscular ejaculatory duct which opens into the rectum to form the cloaca.
- This duct bears a numbers of prostatic glands whose secretion helps in copulation.

e) Penial setae –

- The penial setae are paired muscular pocket –like outgrowths from the dorsal wall of cloaca.
- The penial setae help the transference of sperm during copulation.

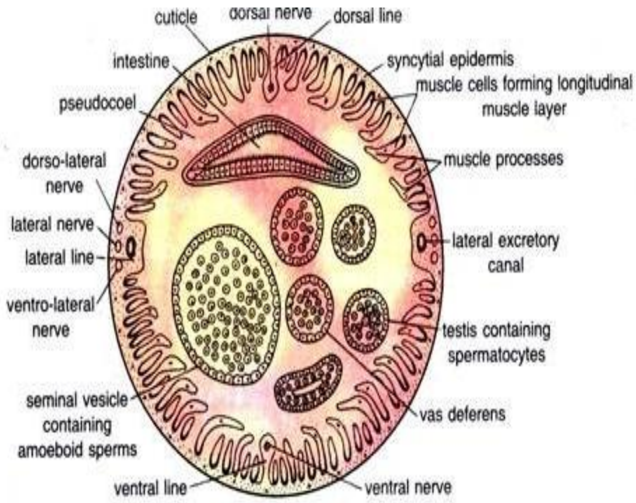


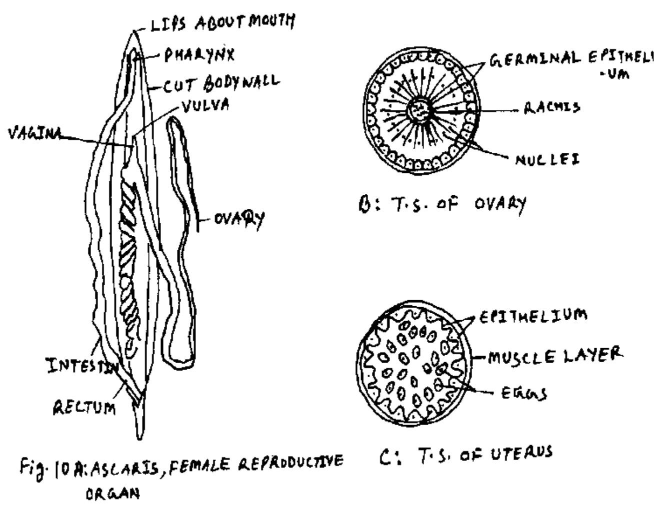
Fig.6.10-E Ascaris: T.S of Mature Male

Female Reproductive Organs:-

The female reproductive organ are-

a). A pair of ovaries

b). A pair of oviducts



c). Two uteri

d). A vagina

a) Ovaries- The paired ovaries of Ascaris are long, thread-like and highly twisted tube like and terminate blindly in the pseudocoel.

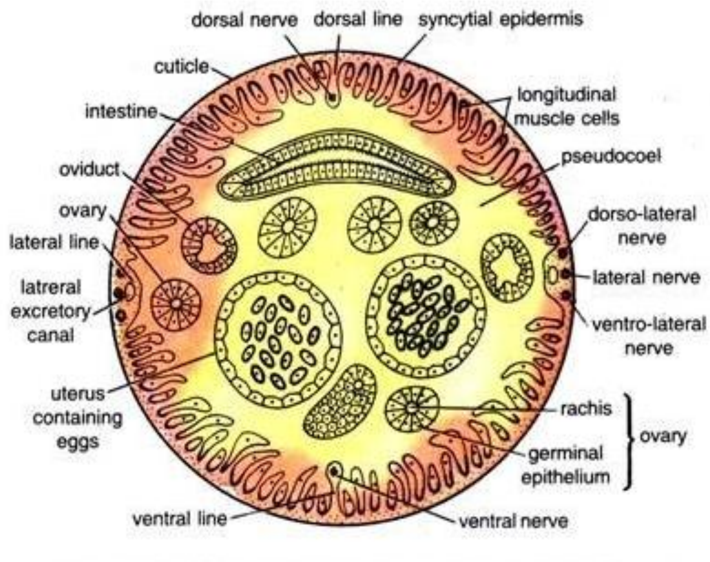


Fig.6.12-D Ascaris: T.S of Mature Female

b). Oviducts- The oviducts are two thin ducts very similar to the ovaries These open into the uteri.

c). Uterus- Each oviduct leads into a long, wide and much coiled uterus, having muscular wall.

d). Vagina-

- The two uteri and open into a short median, muscular vagina lined with cuticle.
- The vagina opens by a transverse gonopore or vulva which lies mid-ventrally about 1/3 of the length from the anterior end.

Life History of *Ascaris:-*

Ascaris is an intestine parasite of man. Its life history is simple and its completed is one host (monogenetic) only.

1. Copulation-

The male and female organisms copulate inside the host intestine and sperm are passed into the vagina.

2. **Fertilization-**

- These move through uterus and fertilised the eggs.
- Eggs are fertilized in the oviduct or in upper part of uterus.

- The fertilized eggs are surrounded with highly resistant, chitinous egg-shell and an irregular coat of albumin.

3. Egg Laying-

- The eggs are laid in the host intestine.
- These are deposited out along with host faces.
- A female Ascaris is recorded to lay as many as 27,000,000 eggs.
- One female may lay from 15,000 to 2, 00,000 eggs daily.

4. Eggs nature-

- Eggs of Ascaris are about 40-75 (microns) in size and elongated eplliptical or oval in form.
- The eggs become stained yellowish or brown in the intestine.
- These are enclosed in thick, transparent, chitinous egg shell and a coarsely laminated albumin coat.
- The covering is resistant to chemicals and environmental changes.
- These eggs can remain dormant for years together in unfavorable environmental conditions.

6.4.3-. Early development:-

- The stage of early embryonic development, say the cleavage or segmented, start in the soil.
- The pattern of cleavage is spiral and determinate.
- The fertilised eggs undergo two cleavages to form four cells or blastomeres.
- The first division is transverse producing an upper dorsal cell AB and a lower ventral P_1.
- The lower cell divides horizontally into upper cell EMST and lower cell P_2. Thus the four –celled embryo has T-shaped appearance.
- The P2 cell shift towards right and comes to lie in front of the upper cell EMST. The A and B cells divide together into right and left cells and by further divisions form the ectoderm of the embryo.
- The EMST and P2 cells divide into E, MST, P3, and C cells. The off springs of cell E form the endoderm, while the descendants of EMST constitute the mesoderm and a part of ectoderm.

- The cell P3 divides into P4 and D. The cell C and D divide and contribute to the ectoderm and mesoderm.
- The cell P1 divides into G1 and G2 and forms the primordial germ cell.\
- Thus blastula stage is attained. It undergoes gastrulation by invagination and finally develops into an active juvenile, representing the rhabditoid stage.

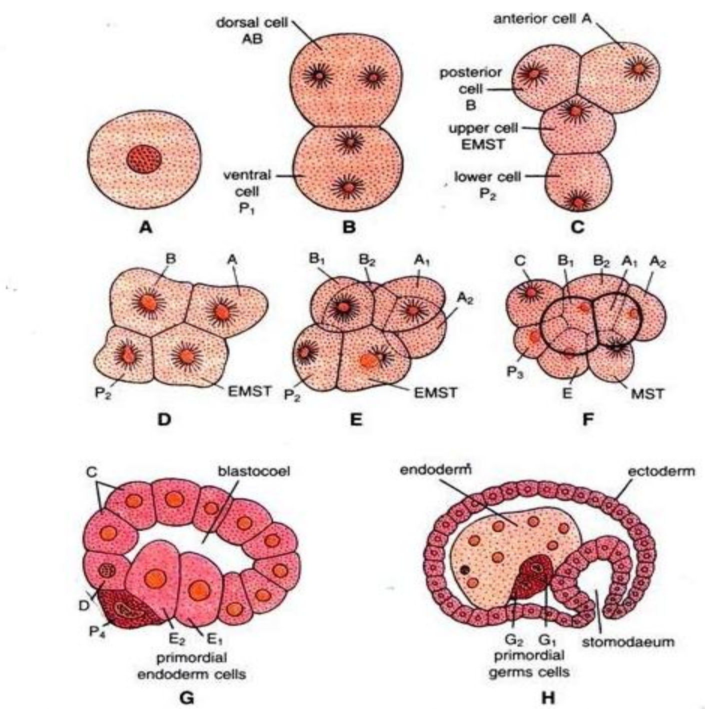


Fig.6.13 Ascaris: Stage of Development.(a) Zygote (b)Cell stage (c) 4-cell stage(T- shaped)(d) 4-cell stage (rhomboidal) (e) 6-cell stage (f) 8-cell stage (g) median sagittal Section through blastula (h) median sagittal section through the embryo after invagination of stomodaeaum & the primordial germ cell.

Under favorable condition of temperature, moisture and oxygen supply, it requires 10-14 days to reach the 2^{nd} stage larva. After a week or so it moults inside the egg shell and changes into the second stages larva.The hatching and further development of the larva is possible only if the egg enters the final host.

4. Infection-

- There is no secondary host in the life history of *Ascaris.*
- The infection to final host is effected when the eggs are swallowed accidentally along with contaminated food, water or raw vegetables.

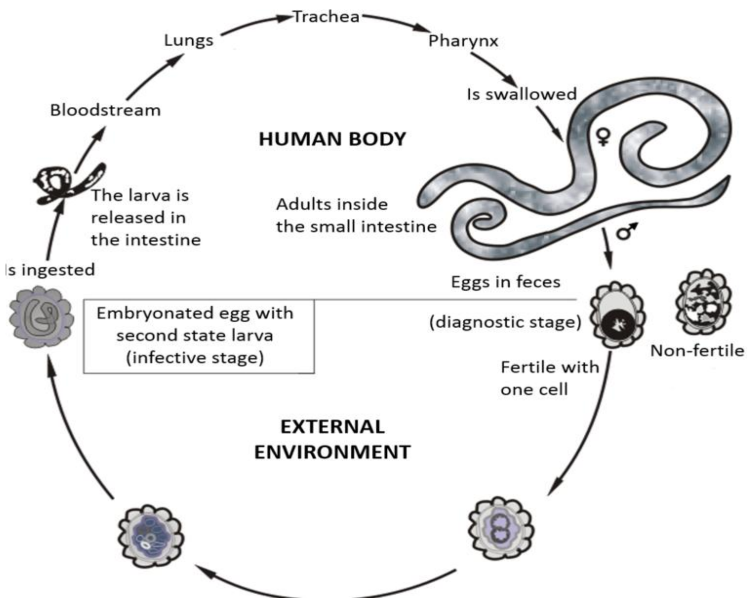


Fig.6.14 Ascaris: Life Cycle

- On reaching the duodenum the 2nd stage rhabditoid larva hatches out of the egg.
- The larva is about 0.2 to .3 mm long with a well developed canal, nervous system and the excretory system.
- Before setting down into the intestine this larva pursues a migratory course through the host body and moults twice.

Primary Migration:

- The 2nd stage larva after hatching out of the egg penetrates the mucous membrane of the intestine and enters the blood stream.
- It is carried to the liver through hepatic portal circulation and from liver it reaches the heart.
- The pulmonary artery, them, carries it to the lung.
- It attains a size of about 1-2mm. After moulting, it again starts its migration.

Secondary Migration:

- Here they grow and moult to become 3rd stage larvae which moult again to become 4th stage larvae.
- From alveoli the larva travels along the trachea into the pharynx.
- It irritates the pharyngeal wall and causes coughing.
- Within 6-10 weeks it becomes sexually mature.

- They grow into adult males and females and attain sexual maturity. The total life of the parasite in the host averages only nine months to a year.

The life history of *Ascaris lumbricoides* can be represented as:

Adult male and female→ fertilisied eggs pass out→ larvae develop in egg shell
↓
Swallowed by man
↓
Intestine where juveniles hatch
↓
Bore through intestine
↓
Mesenteric veins
↓
Hepatic portal vein
↓
Liver
↓
Hepatic vein
↓
Postcaval vein
↓
Right side of heart
↓
Pulmonary artery
↓
Trachea ←Bronchus ←Bronchioles←alveoli where third moulting occurs←Lungs

Grow into adults
↑
Intestine where fourth moulting occurs
↑
Oesophagus
↑
Glottis
↑
Trachea

Pathogenesis or Parasitic Effects:-

1. Not only the adult but also the larvae pursuing the migratory course are pathogenic.

2. The larvae inside the lungs cause inflammation and produce severe and fatal pneumonia. Sometimes their presence causes fever, anaemia, leucocytosis and eosinophillis.

3. The mature worms, of course, are not very fatal and in some cases these do not even disturb the life activities. But when present in large numbers these are responsible to cause abdominal discomfort and acute colic pain.

4. Diarrhea and slight temperature may also be caused.

5. These may accumulate in several hundreds and block the intestine or the appendix causing appendicitis.

6. By destroying the intestinal wall these produce peritonitis.

The toxins liberated by the worm cause delirium, convulsions, coma and general nervousness.In general, presence of Ascaris leads to stunt growth and poor memory of the host.The disease caused by Ascaris is generally known as ascariasis.

Diagnoses:-

1. by serological tests.
2. By barium x-ray the presence of the worm in the intestine can be detected.
3. By examine stoll for eggs of the worm.

Treatment:-

1. Piperazine salt is the ideal drug administered for Ascaris.
2. A single dose cures 60-75% of the infection.
3. Other drugs include Thiabendazole, Mebenedazole, Carbamazine and Tetramizole.

Prevention or Prophylaxis

To avoid the infection of Ascaris the following measures should be taken:

1. The use of raw vegetables and contaminated water should be avoided.
2. Sanitary toilet and effective sanitary disposal of faeces should be provided.
3. Raw stems, leaves, fruits and roots, which have been grown by the use of night soil, fertilizer, should be thoroughly washed and properly cooked.
4. Children should be asked to wash their hands carefully and properly before handling the food.
5. Proper hygienic measures should be adopted and sanitary education should be given to the people.

6.7-Self assessment question:-

1. What kind of parasite is Ascaris and it is the causal organism of which disease?
2. Which medicines are used for the treatment of Ascaris?
3. Write notes on: pseudocoel; Muscle cell?
4. Explain briefly the parasitic adaptations of Ascaris?
5. Give a few features of rhabditiform larva of Ascaris?

6.8-References:-

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6.10-Terminal Questions:-

1. What kind of coelom is found in Ascaris?
2. What are distinguishing features of male and female Ascaris?
3. How many lips surround the mouth of Ascaris?
4. Which is the infective stage of Ascaris for man?
5. Where is anus situated in Ascaris?
6. Draw labelled diagrams only :-

(a) T.S. Male Ascaris.

(b) T.S.Female Ascaris.

Multiple choice questions:-

1. Which type of body cavity is found in Ascaris?

(a) Gastrovascular [ ] (b) Pseudocoelom [√] (c) Coelom [ ] (d) None of these [ ].

2. In life cycle of Ascaris, the juvenile hatches out of egg in

(a) Lung [ ] (b) Liver [ ] (c) Intestine [√] (d) None of these [ ].

UNIT 07: PHYLUM- ANNELIDA

7.1-Objectives:-

(1) Understanding the general characters of Annelida and Classification up to order level.

(2) Study of *Nereis* with special reference to structure, reproduction and development.

(3) Study of Metamerism and Parasitic adaptations in *Hirudinaria*.

7.2-Introduction:-

Name of phylum Annelida was first coined by Lamarck (1801) for the higher segmented worms (Gr., annulus - little ring + eidos - form). Annelids are elongated, bilaterally symmetrical and highly organized animals, in which the organs have grouped in to definite systems. Appearance of metamerism represents their greatest advancement, so that they are called segmented worms in order to distinguish them from flatworms (Platyhelminthes) and roundworms (Nematodes) whish are not segmented. Their paired appendages, when present, are never jointed. Their coelom, nephridia and cephalization are better developed than those of the un-segmented worms. They are the first animals to have a closed vascular system. Nervous system is fundamentally similar to that of Arthropoda and embryology is not much different from that of mollusca.

7.3 General Characters and classification of Annelida

7.3.1-General Characters of Annelida:-

- Mostly aquatic, some terrestrial.
- Burrowing or tubicolous.
- Some commensal and parasitic.
- Body elongated, bilaterally symmetrical, triploblastic, truly coelomate and matamerically segmented into similar metamers.
- Epidermis of a single layer of columnar epithelial cells, covered externally by a thin cuticle.
- Body wall dermo-muscular.
- Outer muscle fibres circular, longitudinal.
- Locomotory organs are segmentally repeated chitinous bristles, called setae or chaetae, embedded in skin. May be borne by lateral fleshy appendages or parapodia.
- Coelom, true, schizocoelous. Mostly well developed except in leeches.
- Usually divided into compartments by transverse septa.

- Coelomic fluid with cells or corpuscles.
- Digestive system straight and complete.
- Digestion entirely extracellular.
- Blood vascular system is closed.
- Respiratory pigmants either haemoglobin or erythrocruorin dissolved in blood plasma.
- Respiration by moist skin or gills of parapodia and head.
- Excretory system consisting of metamerically disposed coiled tubes, called nephridia.
- Nervous system with a pair of cerebral ganglia (brain) and a double ventral nerve cord bearing ganglia and lateral nerves in each segment.
- Sensory organs include tactile organs, taste buds, statocysts, photoreceptor cells and sometimes eyes with lenses in some.
- Hermaphroditic or sexes separate, cleavage pattern spiral and determinate.
- Larva, when present, is a trochophore.
- Regeneration is common.

7.3.1-.Classification of Annelida:

Modern classification of phylum Annelida was proposed by Fauchold (1977) and Parker (1980). About 8,700 known species of annelid are divided into four main classes, primarily on the basis of the presence or absence of parapodia, setae, metamers, and other morphological features.

A. Class – Polychaeta (Gr., poly- many + chaite- hair)

- Chiefly marine, some in fresh water.
- Segmentation internal and external.
- Head distinct with eyes, palps and tentacles.
- Setae numerous, on lateral parapodia.
- Clitellum absent.
- Sexes separate.
- Gonads temporary and in many segments.
- Trochophore larva present.

Polychaetes are divided into two subclasses, Erranitia and Sedentaria (Fauvel, 1959).

However, according to Dab (1963), this subdivision is artificial and not a natural one.

1. **Subclass – Erranitia**

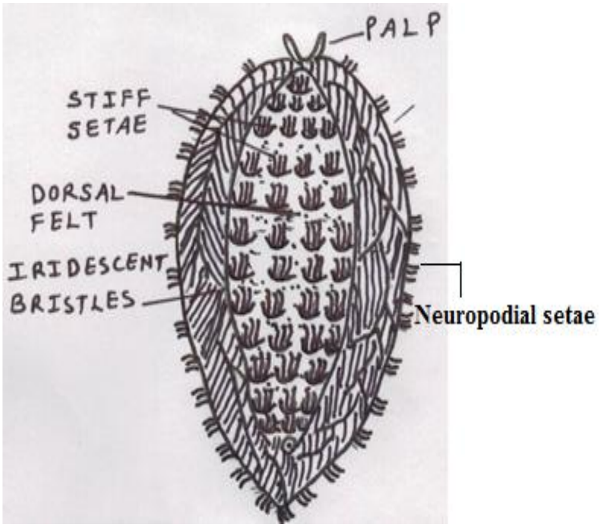


Fig.7.1Aphrodote

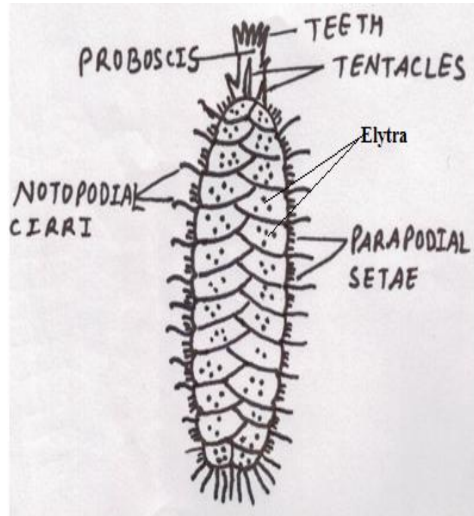


Fig.7.2 Polynoe

Free-swimming, crawling, burrowing or tube-dwelling and predatory polychaetes.

- Segments numerous and similar, except for head and anal region.
- Prostomium distinct with sensory structures.
- Parapodia with acicula and compound setae.
- Pharynx protrusible, enlarged and usually with jaws and teeth.

Examples: Aphrodite (sea mouse, Fig.1), Polynoe (Fig.2), Phyllodoce, Tomopteris, Syllis, Nereis, Glycera, Eunice, Diopatra, Histriobdella.

2. Subclass - Sedentaria

- Sedentary polychaetes living in burrows or tubes.
- Body made of two or more regions, with dissimilar segments and parapodia.
- Prostomium small.
- No acicula and compound setae.
- Pharynx without jaws and teeth.

Examples: Chaetopterus (Fig.7.3), Arenicola (Fig7.4), Owenia, Sabella, Sabellaria, Terebella (Fig.7.5), Amphitrite (Fig.7.6), Pomatoceros, Spirorbis, Serpula.

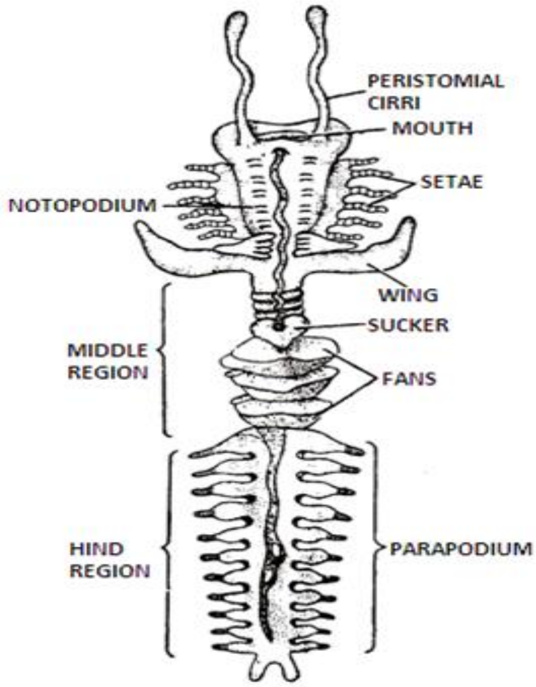


Fig.7.3 Chaetopterus in Dorsal View

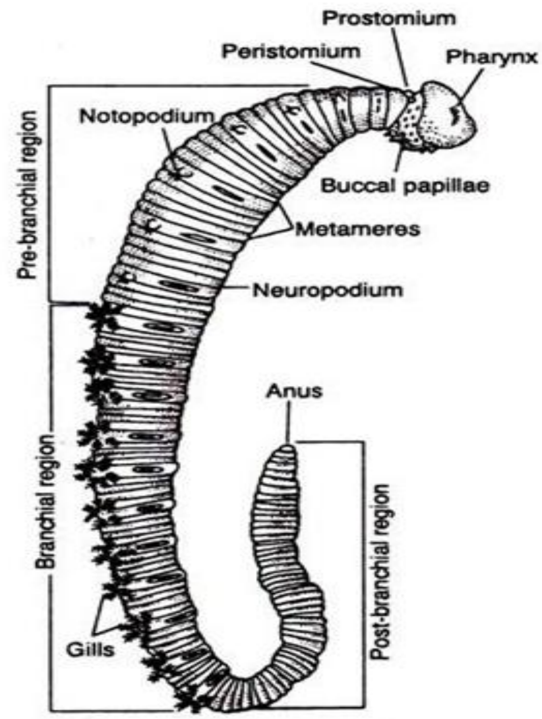


Fig.7.4 Arenicola

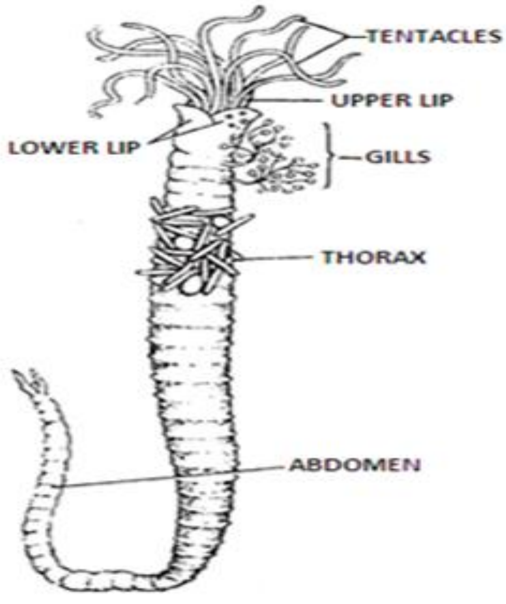


Fig.7.5Terebella

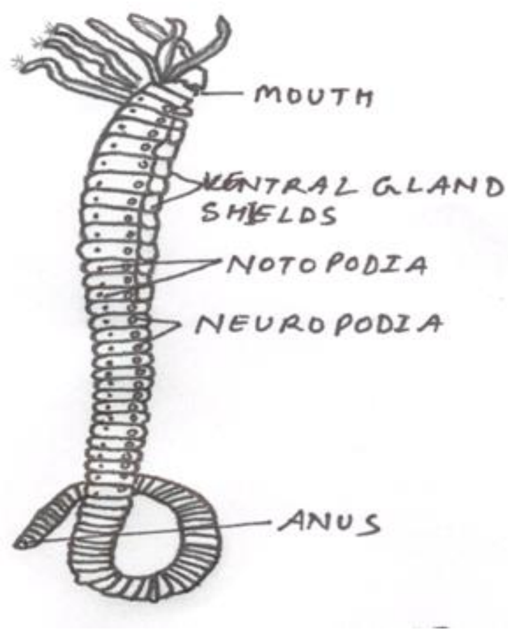


Fig.7.6 Amphitrite

2. Class - Oligochaeta (Gr., oligos- few + chaite- hair)

- Mostly terrestrial, some in fresh water.
- Segmentation internal and external.
- Head distinct, without sensory organs.
- Setae few, embedded in skin.
- Parapodia absent.
- Glandular clitellum present for cocoon formation.
- Hermaphroditic.
- Testes anterior to ovaries.
- Fertilization external (in cocoon); development direct, no larval stages.

1. Order - Plesiopora plesiothecata

- Mostly aquatic.
- Male gonopores on segment immediately following that which contains testes.
- Spermathecae in the testes-containing segments, or nearby.

Examples: Aelosoma, Nais, Dero, Chaetogaster, Tubifex (Fig.7.7).

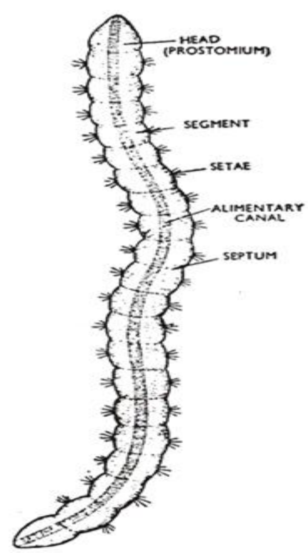


Fig.7.7 Tubifex

2. Order - Plesiopora prosothecata

- Spermathecae far anteriorly to the segment containing testes.

Examples: Enchvtraeus.

3. Order - Prosopora

- Mostly aquatic.
- Male gonopores on the same segment containing testes, or on segment containing the second pair of testes.

Example: Branchiobdella (parasitic).

4. Order - Opisthopora

- Mostly terrestrial earthworms.
- Male gonopores some distance behind the testes-containing segments.

Examples: Lumbricus (Fig.8), Eisenia, Pheretima, Megascolex, Allolobophora, Dendrobaena.

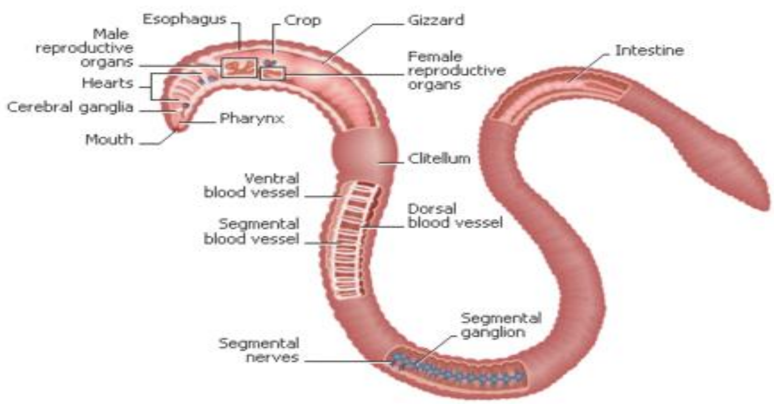


Fig.7.8 Lumbricus

3. Class – Hirudinea (L., hirudo- leech)

- Freshwater, marine or terrestrial.
- Generally ectoparasitc, blood-sucking and carnivorous.
- Body with fixed number of segments (33).
- Each segment subdivided externally into annuli.
- Segmentation external without internal septa.
- Parapodia and setae absent.
- Both anterior and posterior ends of body with suckers.
- Coelom much reduced due to its filling by botryoidal tissue, and forms haemocoelomic sinuses.
- Hermaphroditic with one male and one female gonopore.
- Fertilization internal.

- Development in cocoons, direct without larval stages.

1. Order - Acanthobdellida

- Primitive without anterior suckers, proboscis and jaws.
- Setae present in 5 anterior segments.
- Coelom with compartments.

Example: A single Russian genus and species (Acanthobdella) parasitic on salmon.

2. Order - Rhynchobdellida

- Only aquatic leeches, ectoparasitic.
- A protrusible proboscis with no jaws.
- Coelom without compartments.
- Bloodvasculare system separated from coelomic sinuses.
- Blood colourless.

3. Order - Gnathobdellida

- Aquatic or terrestrial.
- Ectoparasitic blood-sucking leeches.
- Pharynx non-eversible with 3 pairs of jaws.

Examples: Hirudo, Hirudinaria, Haemadipsa.

4. Order - Pharyngobdellida

- Terrestrial and aquatic.
- Some predaceous.
- Pharynx non-protrusible.
- No teeth but one or two style may be present.

Examples: Erpobdella, Dina.

4. Class - Archiannellida (Gr., arch- First)

- About one dozen genera of small, marine worms of unknown affinities.
- Segmentation chiefly internal.
- No parapodia and setae.
- Sexes usually separate.
- Usually trochophore larva.

Example: Polygordius, Dinophilus, protodrilus.

7.4.1- Structure:-

NEREIS OR NEANTHES (A CLAMWORM)

Nereis is a typical polychaete genus, living in burrows in sand or mud, often with clams.

A reason for which its species are commonly known as clamworms or sandworms.

Systematic position:-

PHYLUM	ANNELIDA
CLASS	POLYCHAETA
SUBCLASS	ERRANTEA
GENUS	NEREIS OR NEANTHES
Species	virens

Ecology:-

Nereis is a cosmopolitan marine polychaete, usually found on sandy shores between tidemarks.

Most of the time it lives in U-shaped burrows (up to 60cm), deep and coated with mucus.

Worm maintains constant water current through the burrow by dorso-ventral undulations of its body.

Worm is nocturnal and carnivorous.

During breeding season, the worm leaves its burrow permanently and swims about actively in surface layers of water.

At this stage it is known as heteronereis.

External Morphology

(1)Shape

Body is elongated, slender, bilaterally symmetrical, somewhat broad anteriorly and tapering posteriorly (Fig.9). It is slightly flattened dorso-ventrally, dorsal surface being convex, while ventral surface flat or even somewhat concave.

Size

Length of adult worm varies from a few to about 40cm or even more.

Colour

Different species are differently coloured and the colour may vary with age and sexual maturity.

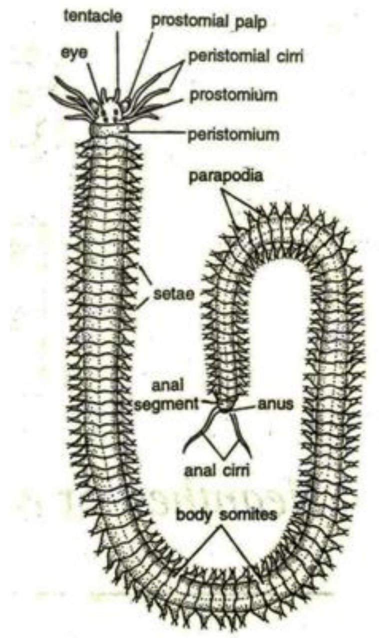


Fig.7.9 Nereis: External feature in dorsal view

N. pelagic is brownish, *N. cultrifera* is greenish and *N. virens* is steel-blue in colour.

(2) Body division

- Body is metamerically divided into a number of metameres or segments arranged in a linear series.
- Number of segments is fairly constant for a species; about 80 in *N. cultrifera* and *N. dumerilli* and about 200 in *N. virens.*

Three distinct regions can be identified in the body: head, trunk and pygidium.

(a) Head:

- Nereis possesses well-developed head corresponding to its active life and predaceous habit.
- It lies at the anterior end and consists of two parts: peristomium and prostomium.

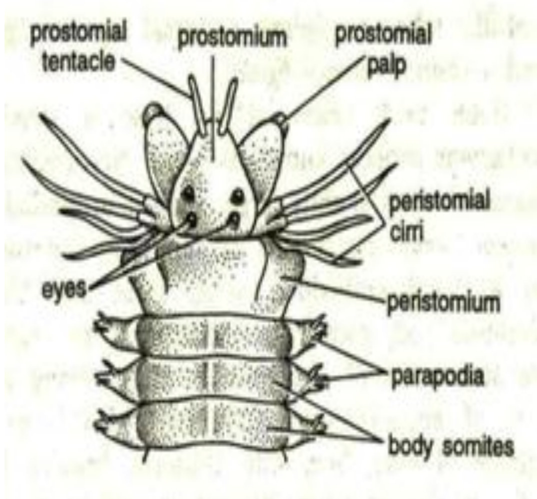
(b) Trunk:

- It comprises practically the entire body segment or pygidium.
- It consists of 80-200 similar segments, each broader than being long and characterized by the presence of a parapodium on each lateral side.

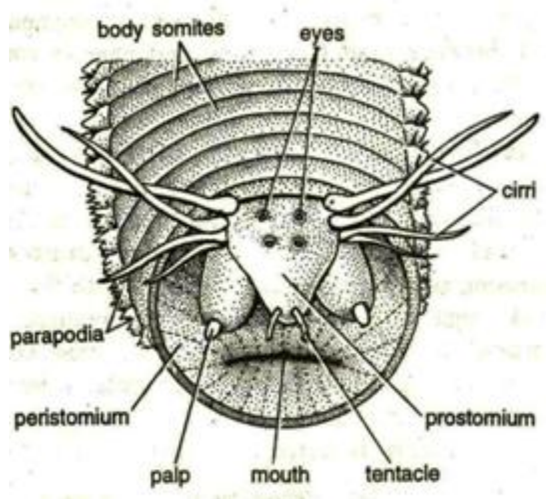
(c)Pygidium:

- This is represented by the last body segment, also known as tail or anal segment.

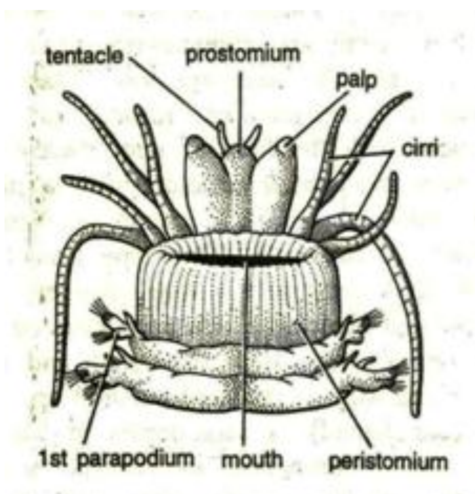
- It bears a terminal anus, a pair of long filamentous, ventral appendages, the anal cirri, and several minute sensory papillae.



(A) Dorsal View



(B) Frontal View



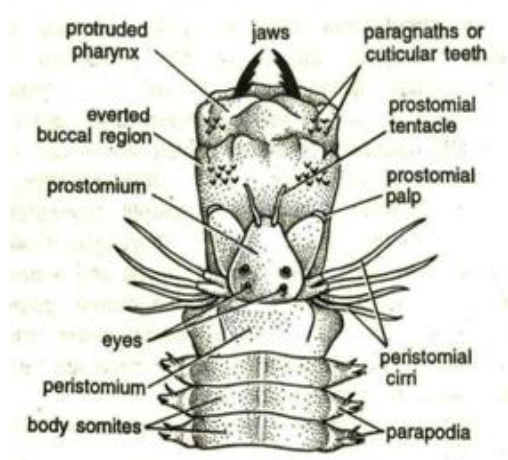
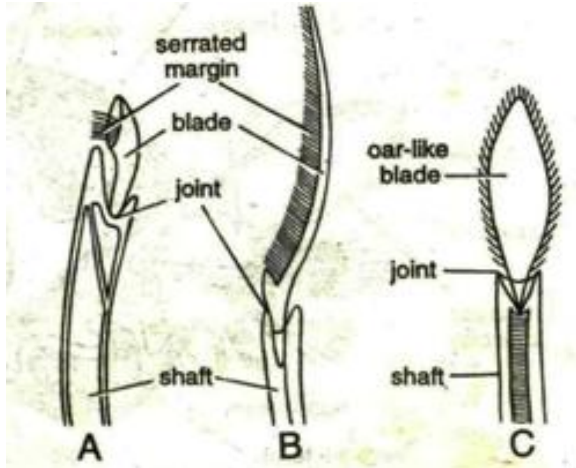


Fig 7.10

(C) Head in Ventral View *(D) Head in dorsal view with everted probosascis*



Typical Long Bladed Oral shaped Heteronereis

Fig.7.11 Nereis kind of setae

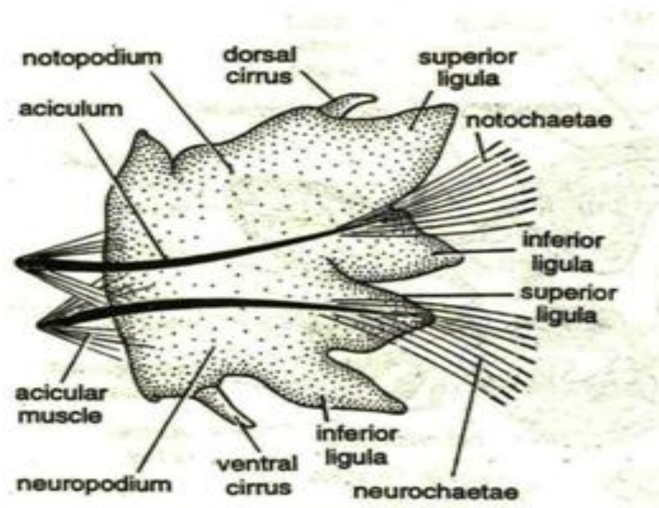


Fig 7.12 Nereis: Parapodium

Body Wall and Musculature:-

The body wall consists of four layers: cuticle, epidermis, musculature and peritoneum.

- **Cuticle:** It is the outermost, thin, tough and chitinous layer and is perforated by numerous minute openings of epidermal gland cells.
- **Epidermis:** It lies beneath cuticle and rests on a thin basement membrane. It consists of a single layer of tall columnar supporting cells and some scattered glandular and sensory cells. Epidermal gland cells secrete mucus.

- **Musculature:** Nereis has a well-developed musculature consisting of circular, longitudinal and oblique muscles. These are composed of unstriped muscle fibres.

Peritoneum:

- Muscles are lined internally by a thin, delicate layer of coelomic epithelium or peritoneum.
- This layer also lines the coelom externally and is thus also described as the somatic or parietal layer of coelomic epithelium.
- It secretes the coelomic fluid.

7.4.2-Reproductive System

Nereis is dioecious, i.e., sexes are separate. The gonads are neither permanent nor distinct. They are seasonal and develop only during the breeding season (summer months).

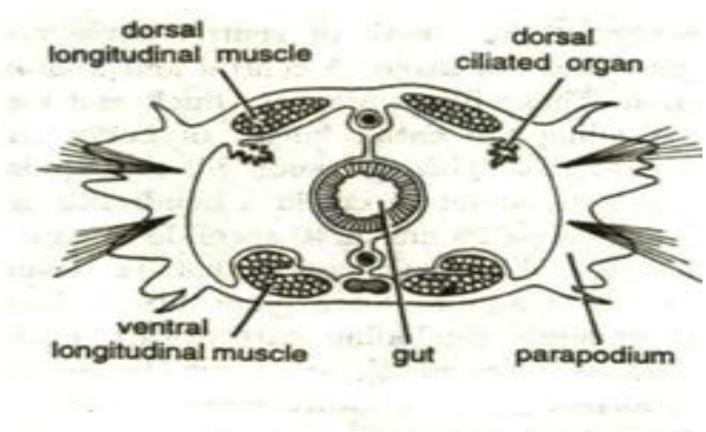


Fig 7.13 Nereis: T.S of a Segment to show the ciliated organs

Epitoky and Heteronereis:-

Epitoky is the formation of sexual individual or epitoke which differs from the parent non-sexual individual or atoke.

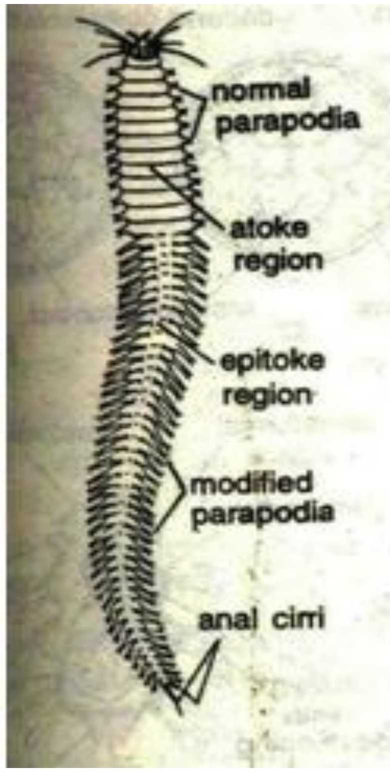


Fig 7.14: Heteronereis

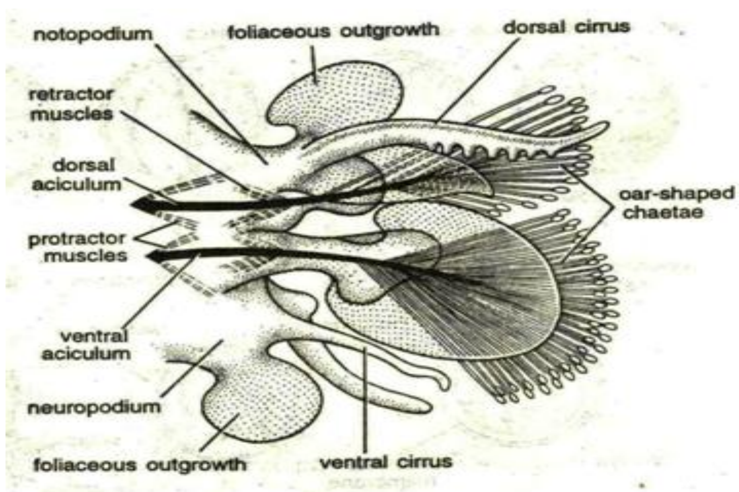


Fig 7.15 Parapodium of Heteronereis

- Heteronereis leaves the burrow, comes up at the surface of water and leads an active free swimming life.
- The eyes are highly sensitive to light.
- The peristomial cirri become longer.
- Parapodia of epitoke region become enlarged.

Significance of Heteronereis Stage:-

- Heteronereis is a sexual phase,
- Swims actively at the surface of sea –water. So, it discharges gametes too far off places in the sea and thus helps in the dispersal of species.

7.4.3- Development:-

Life-History of Nereis

(I) Swarming:-

- Sexually mature individuals or Heteronereis swim to the surface of sea water in order to shed sperms or ova. This ethos is called swarming.
- It generally occurs at night and some species, while swarming, perform a nuptial dance in which both mntales and females swim rapidly in a circle.
- Females produce a substance, called fertilium, which attracts the male and stimulates shedding of eggs.
- In case of *N. succinea*, males first swim to the surface and wait for females.
- When the latter appear, males swim around them shedding sperms. In response, the females get excited and shed ova.

(II) Fertilization:

- Fertilization is mostly external in *Nereis virens* and takes place in sea water.
- *Platynereis megalops* has an altogether different mechanism.
- The male wraps tightly around female, inserts his anus into her mouth and injects sperms.
- Gut of both having been eroded by phagocytes, sperms pass directly into coelom of female where fertilization of eggs occurs.
- Fertilized eggs are shed at once from the posterior end of the female's body.
- This mechanism of internal fertilization has probably evolved in *Platynereis megalops* because its eggs become unfertilizable just after 30 seconds contact with sea water.

(III) Development:-

Development of Nereis comprises three distinct periods.

(a) Pre-larval period:-

- Unfertilized egg of Nereis contains numerous yolk spherules and oil droplets.

- It is covered by a thick, radially striated membrane, called zona radiata, which in turn has another thin delicate membrane around it.
- Outside these membranes is a thick gelatinous coating.
- Soon after fertilization, zona radiata disappears, yolk spherules from animal pole move into vegetal pole (telolecithal condition), egg extrudes two polar bodies, and undergoes cleavage.
- First two cleavages of zygote are equal and vertical and results in four cells or blastomeres, lying in the same plane.

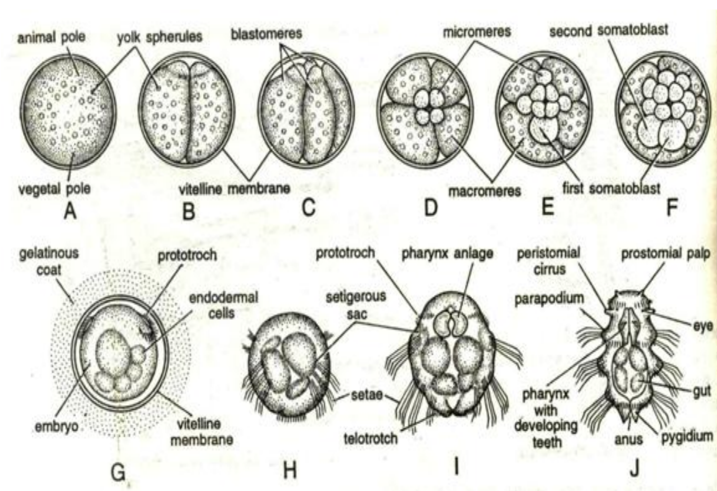


Fig: 7.16 Nereis: Stage in Development

- Cleavage is determinate.
- Third cleavage is unequal and horizontal.
- It produces four small, yolk free micromeres towards the animal pole and four large, yolky macromere’s towards the vegetal pole.
- Fourth, fifth and sixth cleavages are also unequal and horizontal.

(b) Larval period –

- After gastrulation, ciliated embryo rapidly develops into a larval stage, called trochophora.
- After 24 hours of development, the trochophora structure begins to appe.

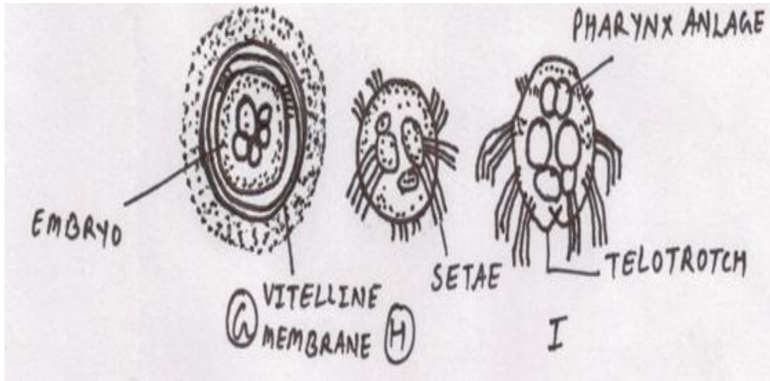


Fig: 7.17 Young trochophore before hatching, Post trchophore & older larva hatching Stage

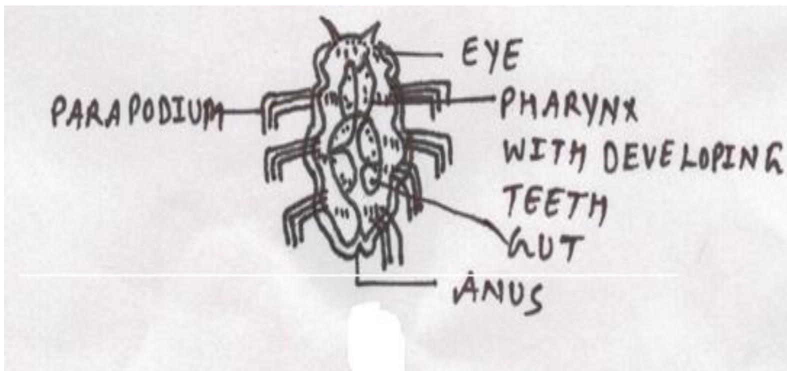


Fig: 7.18 later larvas after three week

(c) Post-larval period-

- Post trochophore larva swims actively for a few days and feeding on microorganisms (Fig.17).
- While swimming it undergoes metamorphosis to change into the adult.

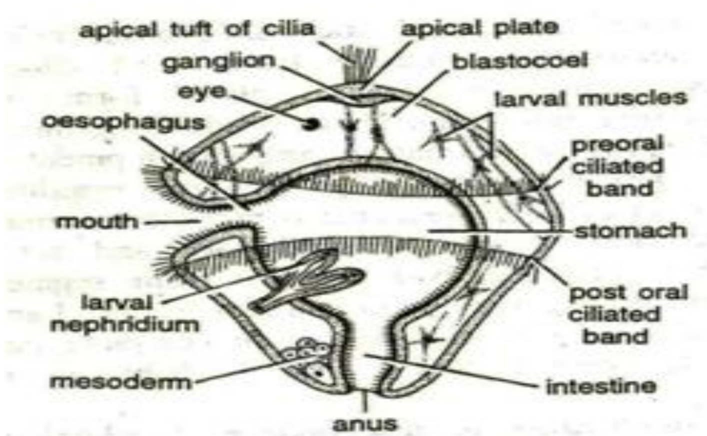


Fig: 7.19 A Typical trochophore Larva

- Its preoral apical portion develops into the prostomium of adult.
- First segment becomes the peristomium and the last segment the pygidium.
- Ciliary bands disappear and larva grows in size with the addition of new segments just in front of pygidium.
- In the burrow it grows further adding new segments and becomes the burrowing adult worm.

7.5- Metamerism and Parasitic adaptations in Hirudinaria

HIRUDINARIA GRANULOSA (The Indian Cattle Leech)

- Class Hirudinea comprises of leeches which are perhaps the most specialized annelids without parapodia and setae but with suckers.
- About 300 species of leeches are known to occur in the tropical and temperate parts of the globe. Most of them are freshwater, while some are marine or terrestrial.
- Most of leeches are ectoparasitic, living on the blood of vertebrates, while some are predaceous, feeding on worms, snails, insect larvae, etc.
- The genus Hirudinaria includes four species of Indian cattle leeches: *Hirudinaria viridis*, *H. javanica, H. manilensis* and *H. granulose.*

Hirudinaria granulose

Systematic Position

PHYLUM ANNELIDA
CLASS HIRUDINEA
ORDER GNATHOBDELLIDA
FAMILY HEIRUDINAE
GENUS HIRUDINARIA
Species granulose

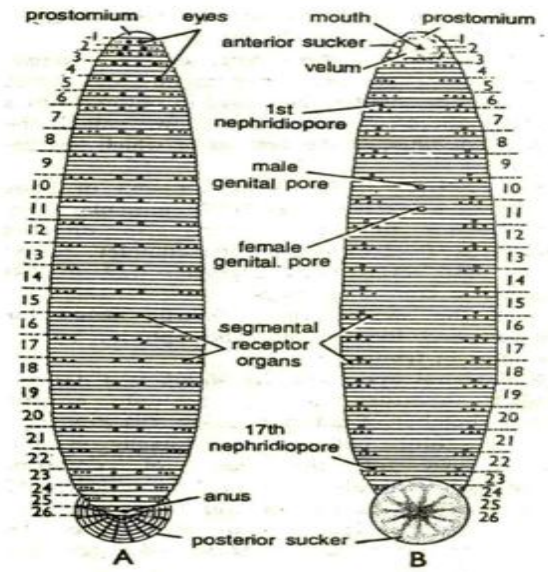


Fig7.20 Hirudineria: External Feature (A) Dorsal view (B) Ventral View

Ecology:-

- *Hirudinaria granulose,* the Indian cattle leech, is found in India, Burma, Sri Lanka, Pakistan and Bangladesh.
- It occurs in fresh-water ponds, lakes, tanks, swamps and slow streams, where it either swim by vertical undulations or grips objects with its suckers and moves by looping.
- Like most ectoparasitic leeches, it has a blood-sucking (sanguivorous) habit, feeding on the blood of fish and frogs and also of cattle and men, who happen to enter the water inhabited by it.
- Though hermaphroditic, leeches copulate to bring about cross-fertilization.
- Eggs are deposited in cocoons.
- Body is elongated, dorso-ventral-flattened and vermiform with flat ventral and convex dorsal surfaces (Fig.18).
- Development is direct, i.e., there are no free larval stages in the life-history.

7.5.1-Metamerism in *Hirundinaria:-*

In annelids the body consists of segments arranged in a linear repetitive fashion. This linear repetition of body segment is called metamerism. Each section or part of the body is called segment, somite or metamer (Fig.20).

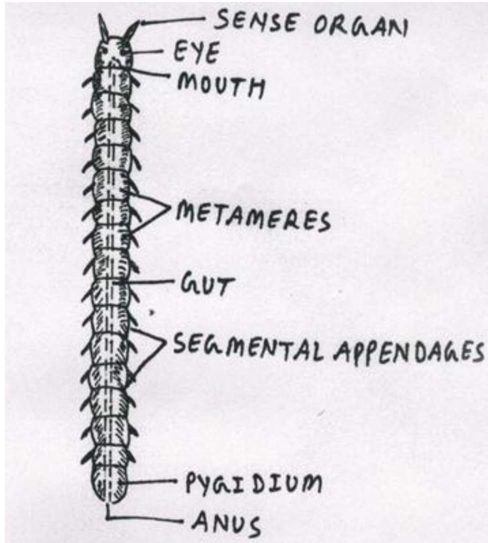


Fig: 7.21 Diagram showing metameric segmentation in an Annelid

Metamerism segmentation is first seen in animal kingdom in the body of annelids. In metameric segmentation, body is divided into numerous body segments externally by groove and internally by septa. All the segments or metameres are same age and have all body organs such as musculature, blood vessels, nerves, ganglia, excretory organs and gonods etc. In earthworm and Nereis even the coelom is divided into segmental compartments by inter segmental septa. But in annelids, the metamerism is limited to the trunk region of the body.The head with brain and sense organs is represented by prostomium and the terminal portion at the posterior end with anus is represented by pygidium.This two portions i.e., prostomium and pygidium are not true metameres. In annelids metameism is described as bring complete because all segments or metameres have segmented blood vessels, nerve, nephridia and coelom. Such segment also called homonomous.

Significance of Metamerism:-

a) Metamerism helps in locomotion in various ways. Annelids are able to locomotion like swimming and creeping by the help of the contraction of body wall muscles of body segments and coelomic fluid.
b) Coelomic fluid in coelomic chamber acts as an hydraulic skeleton during burrowing and swimming.
c) In higher classes like Arthropods and Chordates, each metamere of body is specialized for different functions. Hence, higher and complex animals evolved due to metamerism.

7.5.2-Parasitic Adaptations in *Hirundinaria*:-

Most leeches lead a semi-parasitic life, sucking blood of vertebrates.

Correspondingly, they show several parasitic adaptations in their habits, habitat and structure.

- **Habitat:**

  It inhabits fresh water ponds and pools visited frequently by men and cattle.

  Moreover, it prefers to live in shallow waters where it can easily hide under weeds, logs and stones.

- **Habits:**

  Its active swimming habit is ideal for searching the host and escaping from predators.

- **Shape:**

  Body is long, flattened and devoid of appendages, like parapodia, and hence suitable for aquatic life.

- **Slime gland:**

  These are present in body wall.

  Their secretion keeps the body moist and slippery to prevent desiccation and reduces friction during locomotion.

- **Suckers:**

  These serve as organs of locomotion and also provide firm adhesion to the host's body at the time of feeding.

- **Jaws:**

  The three jaws are specialized weapons for inflicting a painless triradiate wound on the host's skin for sucking blood.

- **Suctorial pharynx:**

  Mouth leads into a muscular pharynx connected with body wall by radiating muscles. Cavity of pharynx alternately expands and contracts to serve as a suction pump so that blood, oozing from the host's would, is sucked in.

- **Hirudin:**

  Slivary glands of leeches secrete an anticoagulating substance, called hirudin or anticoagulin, It prevents clotting of blood while the leech is taking its meal, thus ensuring a continuous supply of blood (vampire bats and hook worms also secretes a similar substance to facilitate their feeding).

- **Spacious crop:**

  Chances of getting a host are remote, so that supply of nutrient is very irregular and a matter of chance. Digestive tract is accordingly modified. At the time of single meal a leech obtains many times its own weight of blood, which is sufficient for several months or even a year. To accommodate this blood, the crop is spacious thin-walled elastic and capable of great dilatation. It is also produced into lateral pouches or storing pockets. It can, therefore, hold enough blood to last for months. However, some species that parasitize aquatic vertebrates remain attached to their hosts.

  Slow digestion:

  After a meal, leech drops off, remains torpid and digests blood at a very slow pace. Last chamber of crop opens behind into stomach through a sphinctered aperture, so that blood passes from crop into stomach with extreme slowness. Digestion of a "crop full of blood" takes many months and thus a single meal lasts for several months. For this reason also leeches lack elaborate digestive juices and enzymes.

- **Sense organs:**

  These are well-developed and provide the animal with greater opportunities of life.

- **Hermaphroditisim:**

  This doubles the rate of reproduction as, after copulation, both individuals lay eggs.

- **Development:**

  It takes place within the cocoon which serves as a protective covering.

  Further, development is quick, and completed within a fortnight to ensure the maintenance of a regular population.

7.6- Self assessment question:-

(1)Write down the note on Segmentation of Hirudinaria?

(2) Note on Botryoidal tissue?

(3) Write down the note on Coelom of leech?

(4) Write down the note on ciliated organ?

(5) Write down the note on Formation of ootheca in Hirudinaria?

(6) Note on Parasitic adaptive features of Hirudinaria?

(7) Describe briefly about the annelids?

(8)What is hypodermic impregnation? In which genera is this phenomenon found?

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7.11-Terminal Questions

1. Write important adaptive features of Hirudinaria?

2. Describe the features indicating the adaptations of leech to lead an ectoparasitic life?

3. Which organs does the female reproductive system of leech comprise? Write the location of ovaries?

4. Write, in brief, about the mode of locomotion of leech?

5. Write a short note on haemocoelomic system of leech?

UNIT 08: PHYLUM ARTHROPODA

8.1- Objectives

1. To understand different body parts and their functioning.
2. Detailed study of some important arthropoda.
3. Understading habitat of *Palaemon*.
4. Understanding the nervous system and reproductive system of *Palaemon*.

8.2- Introduction

Phylum arthropoda (Gr., arthros = joint + podos = foot) is the largest phylum and most varied in the animal kingdom. Von Siebold gave the name arthropoda. It includes well over one million described species and many million remain unstudied. Some of the more well-known arthropods include insects, crustaceans, spiders, scorpion and centipede as well as the fossil trilobites. Arthropods are mainly terrestrial but marine and freshwater species are also well known. Arthropoda varies tremendously in their habitats, life histories, and dietary preferences.

Arthropod bodies are divided into segments. However, a number of segments are sometimes fused to form integrated body parts known as tagmata. This process of fusion is called tagmosis. The head, thorax, and abdomen are examples of tagmata. Exoskeleton serves as protection and provides places for muscle attachment. Arthropods must molt because their exoskeletons don’t grow with them. However, in most species some appendages have been modified to form other structures, such as mouthparts, antennae, or reproductive organs. Arthropod appendages may be either biramous (branched) or uniramous (unbranched). In insects, the anterior portion of the heart is extended into a tube that is called an aorta which directs the blood forward as it goes out into the body cavity. Arthropods have a well-developed, mesodermal, solid nerve cord, ventral and well-developed sense organs. They range in size from microscopic plankton to life-forms that are a few meter long. Arthropods primary internal cavity is known as hemocoel, which accommodates their internal organs, and through which their haemolymph - analogue of blood - circulates; they have open circulatory systems.

Respiration occurs in various ways for e.g. some species have gills, while others employ tracheae, or book lungs. The tracheal respiratory system consists of external openings called spiracles that are linked to a system of branched tubules which allow respiratory gases to reach internal tissues. Arthropods are characterized by a brain as well as a nerve ring around the area of the pharynx, in the oral cavity. A double nerve cord extends backwards along the ventral surface of the body, and each body segment is associated with its own ganglion, or mass of nerve cells. Generally, the sexes are separate in phylum arthropoda. Fertilization usually occurs internally, and most species are egg-laying. While some species exhibit direct development, in which eggs hatch as miniature versions of adults, other species pass through an immature larval stage and undergo a dramatic metamorphosis before reaching adult form. Arthropods contribute directly (as food) as well as indirectly (crop pollination) to human food supply chain. Some specific species are known to spread severe disease to humans, livestock, and crops.

8.3- GENERAL CHARACTERS

1. Arthropoda is bilaterally symmetrical, triploblastic and metamerically segmented animals.
2. Body can be divided into head, thorax and abdomen; head and thorax are often fused to form Cephalothorax.
3. Body is covered with a thick chitinous cuticle forming an exoskeleton.
4. Body segments usually bear paired and jointed appendages.
5. Coelom largely a blood-filled haemocoel.
6. Muscles are mostly striated, usually capable of rapid contraction.
7. Digestive tract is complete. The mouth and anus lie at opposite ends of the body.
8. Circulatory system is open with dorsal heart and arteries and blood sinuses.
9. Respiration through by general body surface, by gills in aquatic forms, by tracheae and by book lungs.
10. Nervous system has dorsal nerve ring.
11. Excretory organs are malpighian tubules (in insects) and green glands (in Crabs and prawn).
12. Cilia are absent from all parts of the body.
13. Sexes are generally separate.
14. Fertilization is internal, oviparous and ovoviviparous
15. Parental care is well marked in many arthropods.

8.4- CLASSIFICATIONS

Arthropoda is a heterogenous group including a wide variety of animals. Since there are divergent views concerning their phylogeny, therefore there is no definitive system for classifying this phylum. However we can still classify it under following:

Subphylum I: Trilobitomorpha (Gr., tria=three + lobos= lobe+morphe= form)

1. Mostly marine and bottom dwellers arthropods.

2. Fossil trilobites.

3. Body can be divided into 3 lobes by 2 longitudinal furrows.

4. Biramous appendages are there on all segments except the last one.

Examples: *Triarthrus*, *Dalmanites*

Subphylum II: Chelicerata (Gr., Chele= claw+ Keros=horn+ata=group)

1. Body differentiated into an anterior prosoma (cephalothorax) and an opisthosoma (abdomen).

2. There are six pairs of appendages. First pair is of preoral chelicerae with claws, one pair of pedipalps and four pairs are of walking legs.

3. Antennae and jaws are absent.

Subphylum Chelicerata has been divided into two classes:

Class1. Merostomata (Gr., meros = thigh + Stoma = mouth)

1. Marine and aquatic chelicerates.

2. Median, simple and lateral compound eyes.

3. Abdomen with 5 or 6 pair of appendages.

4. No malpighian tubules.

Subclass 1. Xiphosura (Gr., xiphos = sword + aura = tail)

1. Cephalothorax with a broad, horse-shoe shaped carapace.

2. Abdomen is unsegmented and ends in a long telson.

Examples: *Limulus* (king crab or horseshoe).

Subclass 2. Eurypterida (eurys = broad + pteryx = wing)

1. Extinct, marine and giant water scorpion.
2. Abdomen has twelve segments.
3. Cephalothorax is small.

Examples: *Eurypterus* and *Pterygotus*.

Class 2. Arachnida (Gr. Arachne = spider)

1. Terrestrial or aquatic.
2. It has simple and non compound eyes.
3. Cephalothorax (prosoma) with 2 chelicerae, 2 pedipalps and 4 pairs of walking legs.
4. Abdomen without appendages.
5. Respiration by tracheae, book lungs or both.
6. Excretory organs are malpighian tubules.
7. Dioecious, oviparous, courtship before mating.

Arachnida has been divided into following 10 orders:-

Order 1. Scorpionida (= True Scorpions)

1. Cephalothorax covered with carapace; abdomen differentiated into 7 –segmented mesosoma and 5-Segmented metasoma.
2. Respiration by 4 pair of book lungs.

Examples: *Palamnaeus*, *Buthus*, *Androctonus*.

Order 2. Pseudoscorpionida (False scorpions)

1. Tiny sized.
2. Cephalothorax covered with carapace, abdomen 11 segmented; sting and telson absent.

Examples: *Chelifer*, *Microcreagris*.

Order 3. Araneae (True Spiders)

1. Prosoma and opisthosoma are joined by a narrow pedicel.
2. Opisthosoma with 3 pairs of spinnerets. The Telson is absent.

Examples: *Achaearanea* (House spider), *Lycosa* (wolf spider), *Argiope* (writing spider), *Agelena* (funnel-web spider).

Order 4. Solifugida

1. False Spiders, Sun Spiders or Wind Spiders.

2. Prosoma is divided into a large anterior and a small posterior part.

3. Opisthosoma has 10 or 11-segments.

4. Chelicerae large form pincers; male with flagellum for sperm transfer.

Examples: *Galeodes* (Sun Spiders).

Order 5. Palpigradi

1. Small-sized microwhip scorpions.
2. Carapace formed of two plates.
3. Opisthosoma is 11-segmented.

Examples: *Koenenia*.

Order 6. Pedipelpi

1. Whip scorpions.
2. Abdomen 12- segmented. Last segment has a long flagellum.
3. Pedipalps large with terminal pincer.

Examples: *Mastigoproctus*, *Thelyphonus*.

Order 7. Amblypygi

1. Flattened scorpion-spiders.
2. Abdomen 12-segmented, Chelicerae moderate.
3. First pair of legs is long and sensory.

Examples: *Charinus*.

Order 8. Ricinulei

1. Rare, small and heavy bodied arachnids.
2. Chelicerae pincer-like.
3. Opisthosoma 6-segmented.

Examples: *Ricinoides*, *Crytocellus*.

Order 9. Opioliones

1. Spider-like harvest-men.
2. Body is elliptical.
3. Prosoma is broadly joined to opisthosoma.

Examples: *Phalangium*, *Leiobunum*.

Order 10. Acarina

1. Free-living or parasitic.
2. Body is small, oval and unsegmented.

3. Prosoma and opisthosoma are not differentiated.

4. Chelicerae and pedipalps are small.

Examples: *Sarcoptes* (Itchomite), *Ixodes* (sheep tick), *Dermacentor* (dog tick).

Subphylum III. Mandibulata (L. mandibula = mandible + ata = group)

1. Body can be divided into head, thorax and abdomen.

2. Head consists of one or two pairs of antennae, one and two pairs of maxillae and one pair of mandibles.

3. Compound eyes are common.

Subphylum mandibulata has been divided into six classes.

Class 1. Crustacea (Gr. Cursta = shell)

1. Crustacea are mainly aquatic (mostly marine, few freshwater) and few live in moist places on land.

2. Head joined with thorax to form cephalothorax.

3. Exoskleton is chitinous, hard and calcareous.

4. Head 5-segmented with 2 pairs of antennae, 2 pairs of maxillae and 1 pair of mandibles.

5. Respiration takes place through general body surface or gills.

6. Excretion by antennal glands.

7. Sexes are separate or united and development with nauplius stage.

Subclass 1. Cephalocarida

1. Body made of a horseshoe-shaped head and 19 trunk segments.

2. Eyes absent. Antennae short.

3. Hermaphrodite; life-histroy completes in a metanauplius larva.

Examples: *Hutchinsoniella*.

Subclass 2. Branchiopoda

1. Primitive, small-sized and mostly freshwater.

2. Trunk appendages leaf-like and serve for locomotion, respiration and feeding.

3. Antennules and 2nd maxillae reduced or absent.

4. Abdomen ends in a pair of jointed or unjointed caudal styles.

Order 1. Anostraca

1. Fairy shrimps with nineteen or more trunk segments. Only anterior 11-19 segments bear appendages.

2. Eyes stalked and carapace absent.

Examples: *Artemia*, *Eubranchipus*.

Order 2. Notostraca

1. Tadpole shrimps with 25 to 45 trunk segments.

2. Carapace shield-like. Eyes sessile and styles jointed.

Examples: *Lepidurus*, *Apus*.

Order 3 Diplostraca

1. Clam shrimps and water fleas with a bivalved carapace. Carapace does not enclose the head.

2. Eyes sessile or fused. Styles unjointed.

Examples: *Daphnia*, *Cyzicus*.

Subclass 3. Ostracoda

1. Seed shrimps and small-sized mussel with poorly segmented body.

2. Trunk appendages 2 pairs and leg-like.

3. Antennae and antennules and large, used in swimming.

Order 1. Myodocopa

1. Carapace with anennal notches.

2. Antennae biramous.

Examples: *Cypridina.*

Order 2. Podocopa

1. Carapace unnotched. Two pairs of trunk appendages.

2. Antennae uniramous.

Examples: *Cypris*, *Darwinula*.

Order 3. Platycopa

1. Carapace unnotched. One pair of trunk appendages.

2. Antennae uniramous.

Examples: *Cytherella*.

Order 4. Cladocopa

1. Carapace unnotched.

2. Antennae biramous.

Examples: *Polycope*.

Subclass 4. Mystacocarida

1. Primitive and microscopic body.

2. Antennae and antennules prominent.

3. A single median eye present. Compound eyes absent.

4. Abdomen limbless and a pair of caudal styles.

Examples: *Derocheilocaris*.

Subclass 5. Copepoda

1. Body small, divisible into head, thorax and abdomen.

2. Compound eyes absent and median eye present.

3. Antennae smaller and antennules long.

Examples: *Cyclops*, *Ergasilus*, *Caligus*.

Sub-class 6. Branchiura

1. Fish lice; ectoparasites of skin and gill chambers of fishes and some amphibians.

2. Body dorso-ventrally flattened.

3. Head and thorax covered with carapace.

4. One pair of compound eyes present.

5. Antennae and antennules reduced.

6. First maxillae modified into suckers.

7. Abdomen unsegmented and bilobed.

Examples: *Argulus*, *Dolops*.

Sub-class 7. Cirripedia

1. Barnacles, sessile, attached or parasitic.

2. Carapace forms two folds of mantle and covered externally by calcareous plates.

3. Thoracic limbs 6 pairs, cirriform and biramous.

4. Antennae and compound eyes are absent in adult.

5. Antennules become cement glands for attachment.

6. Abdomen rudimentary with caudal styles.

Order 1. Thoracica

1. Hermaphrodite, non-parasitic and with or without stalk.

2. Mantle present with calcareous plates.

3. Thoracic appendages 6 pairs and ciriform.

Examples: *Lepas*, *Balanus*.

Order 2. Acrothoracica

1. Sessile; unisexual; bore into mollusc shells or corals.

2. Mantle reduced to a chitinous disc.

3. Trunk appendages 4 pairs and cirriform.

Examples: *Alcippe*, *Cryptophialus*.

Order 3. Ascothoracica

1. Parasitic in echinoderms and corals.

2. Mantle bivalve or saccular.

3. Appendages are absent but antennules remain present.

Examples: *Synagoga*, *Dendrogaster*.

Order 4. Apoda

1. Parasitic without appendages.

2. Mantle absent.

Examples: *Proteolepis*.

Order 5. Rhizocephala

1. Adult degenerate, parasitic and sac-like.

2. Peduncle forms root-like absorptive branches ramifying throughout host's tissues.

Examples: *Sacculina*.

Sub-class 8. Malacostraca

1. Body large-sized and made of 19 segments.

2. Cephalothorax made of head and one or more thoracic segments.

3. Carapace well formed and absent.

4. Compound eyes sessile or paired.

5. Abdomen ends into telson; caudal styles absent.

Order 1. Nebaliacea

1. Primitive marine crustaceans.

2. Carapace bivalved with an adductor muscle.

3. Instead of 6, there are 7 abdominal segments.

Examples: *Nebalia*.

Order 2. Mysidacea

1. Marine crustaceans.

2. Body elongated, uropods form a fan-tail.

3. Carapace covers almost entire thorax.

Examples: *Mysis* (Opossum shrimp).

Order 3. Cumacea

1. Head and thorax greatly enlarged.

2. Carapace fused to 3 to 4 thoracic segments.

3. Abdomen narrows.

Examples: *Diastylis*, *Cumopsis*.

Order 4. Isopoda

1. Body dorso-ventrally flattened.

2. Head and 1 or 2 thoracic segments form cephalothorax.

3. Carapace absent.

4. Abdomen is usually short.

Examples: *Asellus*, *Oniscus*.

Order 5. Amphipoda

1. Mostly marine crustaceans.

2. Body laterally compressed.

3. Carapace absent; eyes sessile.

Examples: *Caprella*, *Gammarus*, *Cyamus*.

Order 6. Stomatopoda

1. Mostly marine forms.

2. Mantis shrimp; body flattened; carapace small.

3. Abdomen large, broader than cephalothorax.

4. Heart is elongated.

Examples: *Squilla*.

Order 7. Decapoda

1. Marine forms.

2. Carapace well developed.

3. First 3 pairs of thoracic limbs form maxillipedes.

4. Gills in 3 series present on thorax.

Examples: *Palaemon*, *Penaeus*, *Leucifer*, *Astacus*, *Hippa*, *corcinus*.

Class 2. Diplopoda (Gr., diplos = double + pous = foot)

1. Body elongated, cylindrical and divisible into 5 head segments and 4 thorax segments.

2. Mandibles and maxillae 1 pair.

3. Eyes simple and genital openings in the 3rd abdominal segment.

Sub-class 1. Pselaphrognatha

1. Minute millepedes with soft skin bearing rows of scale-like setae.

2. Trunk with 13 to 17 pairs of legs.

Examples: *Lophoproctus*, *Polyxenus*.

Sub-class 2. Pentazonia

1. Last two pairs of legs modified for clasping.

Examples: *Desmus*, *Glomeris* and *Glomeria*.

Sub-class 3. Helminthomorpha

1. Body flattened or cylindrical.

2. One pair of legs of the 7th segment in the male.

Examples: *Julus*, *Polyzonium*, *Apheloria*, *Polydesmus*.

Class 3. Chilopoda (Gr., Cheilos = lip + pous = foot)

1. Body dorso-ventrally flattened and divisible into head and trunk.

2. Head with 1 pair of antennae, 1 pair of mandibles and 2 pairs of maxillae.

3. First pair of legs modified into poison claws.

Subclass (1) Epimorpha

1. Development epimorphic.

2. Adults with 21 or more pairs of legs.

Examples: *Geophilus*, *Scolopendra*.

Subclass (2) Anamorpha

1. Adults with fifteen pairs of legs.

2. Development anamorphic, *i.e.* less number of segments in young than adults.

Examples: *Lithobius*, *Scutigera*.

Class 4. Symphyla (Gr., syn = together + phylon = tribe)

1. Body is slender and made of head and 15 to 22 trunk segments.

2. without eyes.

3. Genital pores located ventrally on the 4th trunk segment.

Examples: *Hanseniella*, *Scutigerella*.

Class 5. Pauropoda (Gr., pauros = small + pous = foot)

1. Less than 2 mm long; eyes are absent.

2. Body divisible into head and 11-12 trunk segments.

Examples: *Pauropus*.

Class 6. Insecta (L., insectus = cut or divided) **Largest group of phylum Arthropoda.**

1. Body divided into head, thorax and abdomen.

2. Head with compound eyes (1pair), antennae (1 pair), mandibles (1 pair) and maxillae (2 pairs).

3. Mouthparts modified for different feeding habits.

4. Respiration by tracheae. Spiracles lateral.

5. Thorax bears 3 pairs of legs and 1 or 2 pairs of wings.

6. Excretion by Malpighian tubules.

7. Unisexual. Fertilisation is internal.

Subclass (1) Apterygota

1. These are primitve wingless insects.

2. Abdomen with cerci and style-like appendages.

3. Metamorphosis is reduced or absent.

Order1. Protura

1. Insects without wings.

2. No antennae, true eyes and metamorphosis.

Examples: *Acerantulus*.

Order 2. Collembola

1. No eyes, tracheae, Malpighian tubules.

2. Mouthparts chewing or sucking type.

3. Abdomen 6-segmented.

4. Metamorphosis absent.

Examples: *Achoruted*, *Sminthurus*, *Springtails*.

Order 3. Thysanura

1. Body covered with minute silvery scales.

2. Antennae long; mouthparts chewing.

3. Abdomen 11-segmented; telson long.

Examples: *Lepisma* (silver fish).

Sub-class 2. Pterygota

1. Wings present.

2. Abdominal appendages absent but cerci present.

3. Metamorphosis complete or incomplete.

Division (a) Exopterygota

1. Wings develop externally as buds.

2. Metamorphosis gradual. Young stages are nymphs

Order 1. Orthoptera

1. Wings 2 pairs. Forewings straight and leathery. Hindwings membranous and folded at rest.

2. Mouth parts chewing.

3. Prothorax large.

Examples: *Periplaneta* (Cockroach), *Poecilocercus* (Grasshoppers), *Schistocerca* (Locust), *Gryllus* (Cricket), *Mantis* (Praying mantis), *Carausius* (Stick insect) and *Phyllium* (Leaf insect).

Order 2. Isoptera

1. Wings 2 pairs. Held flat on back.

2. Mouthparts chewing.

3. Social insects with well developed caste-system.

Examples: *Termites* or white ants.

Order 3. Dermaptera

1. Forelibs small, leahery; hindwings large and semicircular.

2. Mouthparts chewing.

Examples: *Forficula* (Earwig).

Order 4. Ephemeroptera

1. Wings 2 pairs, membranous; forewings longer and triangular; hindwings smaller and rounded.

2. Adult mouth parts vestigial.

3. Abdomen carries long cerci and caudal filament.

Examples: *Ephermera* (Mayfly).

Order 5. Odonata

1. Wings 2 pairs and membranous.

2. Eyes very large.

3. Mouthparts chewing. Predaceous.

Examples: Dragon flies, Damsal flies.

Order 6. Plecoptera

1. Wings 2 pairs and membranous.

2. Antennae long.

3. Mouthparts of chewing type.

Examples: *Isoperla* (Stone-fly) and Perla.

Order 7. Psocoptera

1. Wingless or forewings larger than hindwings.

2. Antennae present.

3. Mouthparts of chewing type.

Examples: Book lice (wingless), Bark lice (winged).

Order 8. Mallophaga

1. Wings absent; body small; head large; eye degenerate; legs clasping.

2. Mouth parts of chewing type.

Examples: Bitings lice of mammals, bird lice.

Order 9. Anoplura

1. No wings; body broad and flat; head small.

2. Mouth parts piercing and sucking type.

3. Ectoparasites on mammals.

Examples: *Pediculus* (Human louse)

Order 10. Thysanoptera

1. Wings 2 pairs, fringed with long hairs.

2. Mouth parts rasping and sucking type.

Examples: *Thrips*.

Order 11. Hemiptera

1. Wingless or wings 2 pairs. Forewings thickened at base, membranous at tip.

2. Mouth parts of piercing-sucking type forming beak.

Examples: *Belostoma* (Giant water bug), *Cimex* (bedbug) and *Ranatra* (water scorpion).

Order 12. Homoptera

1. Wingless or 2 pairs of membranous wings.

2. Mouth parts form a piercing and sucking beak.

Examples: *Aphids*, *Cicadas* ans Scale insects.

Division (b) Endopterygota

1. Wings develop internally in pupal case.

2. Metamorphosis complete with larval and pupal stages.

Order 1. Neuroptera

1. Wings large and membranous.

2. Antennae long and cerci absent.

3. Mouth parts chewing type.

4. Larvae carnivorous. Abdominal gills in aquatic larvae.

Examples: *Crysopa* (Lacewing), *Myrmeleon* (Antlion).

Order 2. Coleoptera

1. Forewings leathery and hindwings membranous.

2. Antennae modified. Mouth parts chewing type.

Examples: Beetles.

Order 3. Mecoptera

1. Wings long, narrow and membranous.

2. Mouth parts chewing type and on a prolonged beak.

3. Tip of abdomen curved and sting-like in male.

Examples: *Panorpa* (scorpion-fly)

Order 4. Trichoptera

1. Wings long, hairy, folded roof-like over abdomen.
2. Antennae long.
3. Mouthparts rudimentary.
4. Larve pupates within a tube.

Examples: Caddis flies.

Order 5. Lepidoptera

1. Wings membranous, covered with overlapping scales.
2. Mouth-parts of sucking type.
3. Life-cycle includes caterpillar larva.

Examples: Butterflies, Moths.

Order 6. Diptera

1. One pair of wings; hindwings knob-like.
2. Mouth-parts of piercing-sucking type or sponging type.
3. Larva limbless and worm-like called maggot.

Examples: *Musca* (House fly), *Drosophilla* (Fruit fly), *Culex* (Mosquito).

Order 7. Hymenoptera

1. Two pair of wings that are membranous and hooked together during flight.
2. Mouth parts sucking or chewing type.
3. Some show social behavior.

Examples: *Apis* (Honey bee), ants, *Vespa* (Wasp).

Order 8. Siphonaptera

1. Small and laterally flattened. Secondarily wingless.
2. Mouth-parts of piercing-sucking type. Legs long, leaping.
3. Ectoparasites on birds and mammals.

Examples: *Pulex* and *Xenopsylla* (Fleas)

Other types of Arthropoda:-

1. **Limulus.** *Limulus* or king crab belongs to the subclass xiphosure and class merostomata of subphylum chelicerata (Fig 1). It is a large-sized marine animal, upto 60 cm long. It lives in shallow waters partly buried in the bottom mud. It feeds on worms,

algae and mollusks. It is bilaterally symmetrical, triploblastic metamerically segmented animal with jointed appendages. The body is differentiated into prosoma and hinged opisthosoma. Prosoma bears a pair of 3-jointed chelicerae and 5 pairs of 6-jointed legs. First four legs are chelate; fifth is non-chelate. The 7th pair of appendages, chilaria are degenerate and of doubtful functions. (Yadav and varshney, 2015). The broad hexagonal opisthosoma is divisible into an anterior 6-segmented mesosoma and a posterior 3-segmented metasoma. Excretion takes place through 4 pair of coxal glands. Sexes are separate. In breeding season males and females copulate in shallow water. Eggs, laid by females in holes in sand, are fertilized by sperms. *Limulus* is found along the eastern coast line of Asia and North America (Kotpal, 2005).

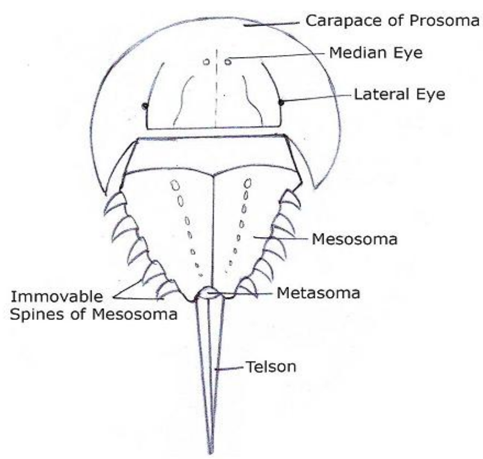


Fig. 1. *Limulus*

Fig 8.1

2. Aranea: *Aranea* belong to the order Araneae of class Arachnida. Body can be divided into prosoma and opisthosoma. Prosoma is covered by carapace that bears 8 simple eyes anteriorly. Ventrally prosoma bears 6 pair of appendages, a pair of chelicerae, a pair of pedipalps and 4 pair of walking legs. Opisthosoma bears spinnerets or spinning organs just anterior to the terminal anus. Respiration happens via book lungs or tracheae or both. Excretory organs are malpighian tubules. The silk secreted by most spiders is used for construction of egg sacs and for constructing webs to trap insects, as well as a guideline for males in finding sexual partners.

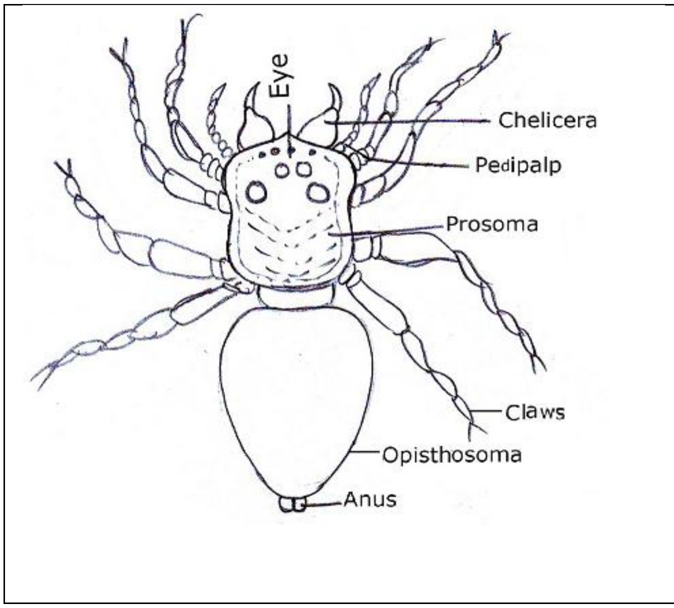


Fig. 8.2 Arenia

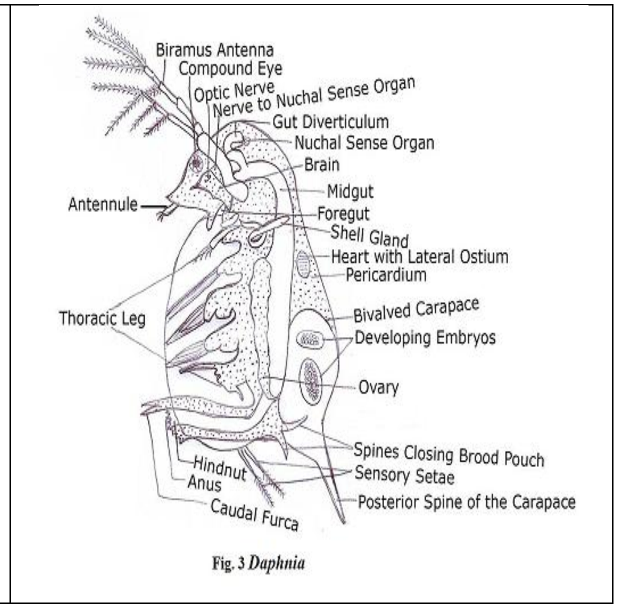
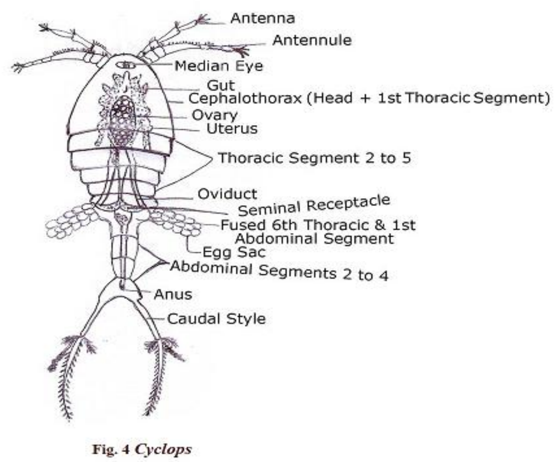


Fig 8.3Daphnia

3. *Daphnia*: *Daphnia*, also called "water fleas", are found in order cladocera of subclass branchiopoda and are sometimes called cladocerans (Fig. 3). Body is about 2 mm long, oval, laterally flattened with a ventral beak on head and a sharp posterior caudal spine. *Daphnia* has a single compound eye and there are normally five or six appendages attached to the thorax. The body is compressed and enclosed in a flattened, transparent carapace. Antennules are much reduced and uniramous. *Daphnia* moves by beating its antennae which are moved by large muscles. They feed on algae, protozoa, bacteria, and decaying organic material. Most are filter feeders that consume phytoplankton which they remove from water using their setose thoracic appendages. A few are carnivores preying on other cladocerans. *Daphnia* swims by rapid jerks of its two large biramous antennae.

4. *Cyclops*: The *Cyclops* is named after one-eyed monster of Greek legend. *Cyclops* is crustacean invertebrate with a hard outer shell. It is the most familiar copepod crustacean found in freshwater ponds. Pear-shaped or elongated body measures 1.5 to 5 mm in length. Head and first thoracic segment become fused to form cephalothorax, which is covered dorsally by a carapace. The cyclops has 5 pair of legs and a divided tail-like appendage called a furca. It is greenish, straw yellow, or grayish in color. It goes jerking through the water usually in very large numbers. The females carry the eggs in little side sacs and they multiply rapidly. The *Cyclops* is often seen near water fleas or *Daphnia*. Many water animals feed upon the *Cyclops*. It has a very important role in the food chain. *Cyclops* serves as intermediate hosts for the guineaworm of man.



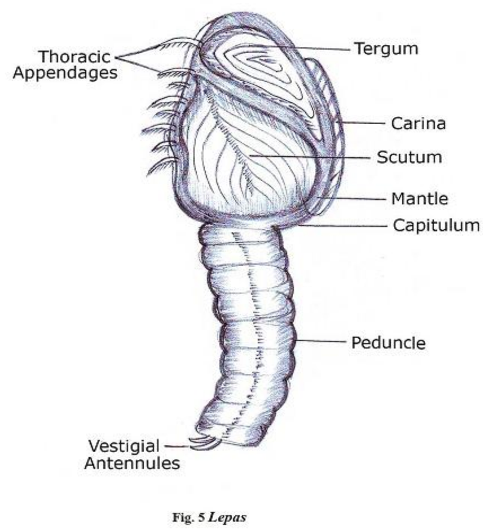
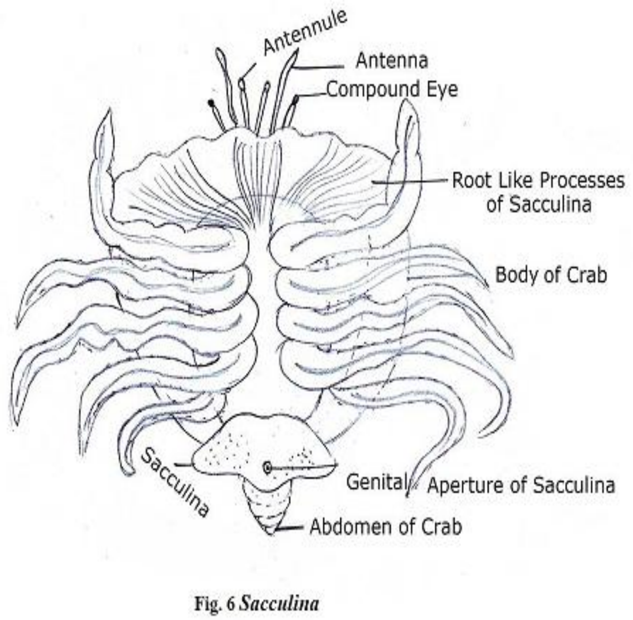


Fig 8.4 Cyclops *Fig.8.5*

5.Lepas**:** *Lepas* is commonly known as “ship or goose barnacle” (Fig. 5). It is a marine animal that inhabits warmer seas. It is found attached to ships and vegetation with the help of peduncle. *Lepas* is bilaterally symmetrical, triploblastic metamerically segmented animal with jointed appendages. The body is covered by a thick chitinous exoskeleton and by 5 calcareous plates-a pair of scuta, a pair of terga and a median dorsal carina. They feed upon minute organisms gathered from water and kicked into mouth by the thread like feet. It is bisexual. Development includes a free-swimming cypris larva (Yadav and varshney, 2015).

6.***Sacculina***: *Sacculina* is commonly known as root-headed barnacle. The adult looks like a large tumour or ovoid sax fastened to the abdomen of crab by a short stalk. Appendages, segmentation, sense organs and alimentary canal etc. are absent. The body is made up of two parts- a thin sac present on the ventral abdomen of the host crab and a peduncle. The female *sacculina* infects a crab. The male *sacculina* lives within the body of the female and fertilize its eggs. Larva is cirripede-nauplius.



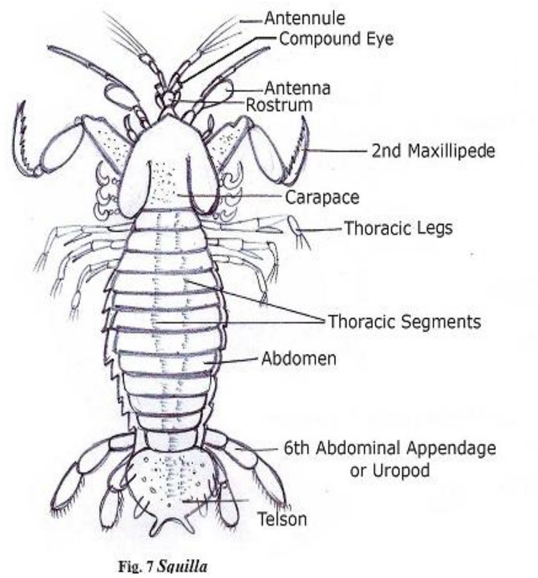


Fig 8.6Sacculina *Fig 8.7Squilla*

7.*Squilla*: *Squilla* is a large marine crustacean and belongs to order stomatopoda of subclass malacostraca (Fig. 7). *Squilla* is active, predatory and nocturnal; it catches hold of the prey with powerful maxillipedes. It is found in burrows in the sand or mud at the bottom of the sea. Body is bilaterally symmetrical, metamerically segmented, triploblastic, dorso-ventrally flattened and 25 cm long. Body is divisible into cephalic, thoracic and abdominal parts. Head bears a pair of stalked movable compound eyes, antennules and antennae. The thoracic region bears 5 pairs of maxillipedes and 3 pairs of walking legs. The second pair of maxillipedes is exceptionally large. The large abdomen is made up of 6 segments and each segment bears a pair of biramous pleopods. The last pair of pleopods are called uropod. It feeds on small fishes, crustaceans, molluscs etc.

8.*Eupagurus*: *Eupagurus* is commonly known as 'hermit crab'. It is found inhabiting the empty shells of gastropods. It leads a commensal life. Cephalothorax is broad and flattened. Head bears a pair of stalked elongated eyes, a pair of large antennae and a pair of short antennules. Thorax bears 5 pair of legs. First, fourth and fifth pair of legs are chelate whereas rest of the legs are non chelate (Verma, 2015). Abdomen appendages of the left side are reduced while those of the right side are absent. *Eupagarus* is a peculiar crustacean having extreme modifications in order to adjust in the coils of molluscan shells.

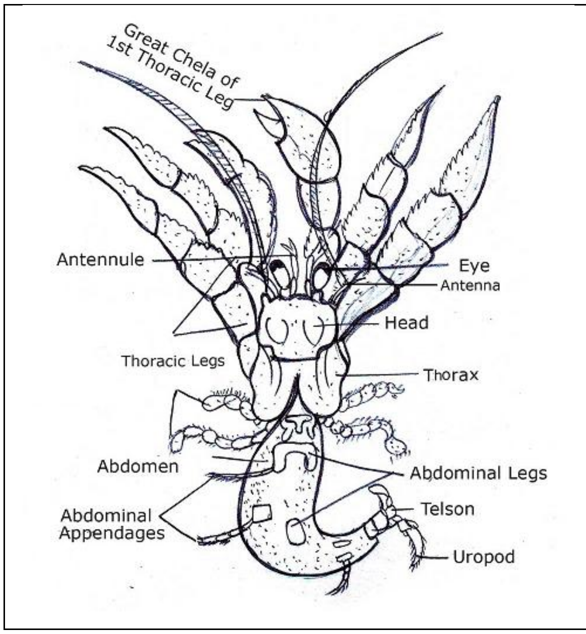


Fig. 8.8 Eupagurus

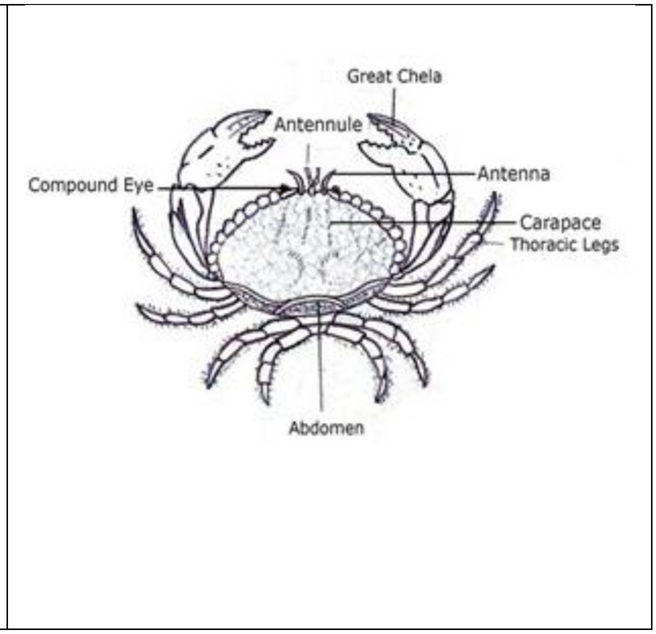


Fig 8.9 Cancer

9.*Cancer*: *Cancer* is commonly called rock crab or true crab (Fig. 9). Body is dorso-ventrally compressed and consists of a cephalothorax and an abdomen. Cephalothorax is broader than long and is covered by a carapace. It bears small antennules, antennae, maxillipedes, compound eyes and thoracic legs. Mouth parts present on the ventral surface are covered by the flat, plate-like third maxillipedes. Fifth pairs of thoracic legs are present. The first pair is chelate where as the remaining are non-chelate. The eggs are carried about by the female attached to abdominal legs (Verma, 2015). Development is indirect through zoea and megalopa larval stages.

10.Gryllus: *Gryllus* belong to the order Orthoptera. *Gryllus* is the common house cricket which lives in damp warm places like under logs, boxes, and stones and in holes behind boods and crevices and in the kitchens. The body can be divided into head, thorax and abdomen. Head bears a pair of compound eyes and a pair of antennae which are filiform and longer than the body. Mouth parts are mandibulate and well-developed. Female possess a well-developed oviposterior that serves for depositing eggs in holes or crevices, devours all sorts of animal and vegetable matter such as clothing paper, skin, fruits and vegetables etc.

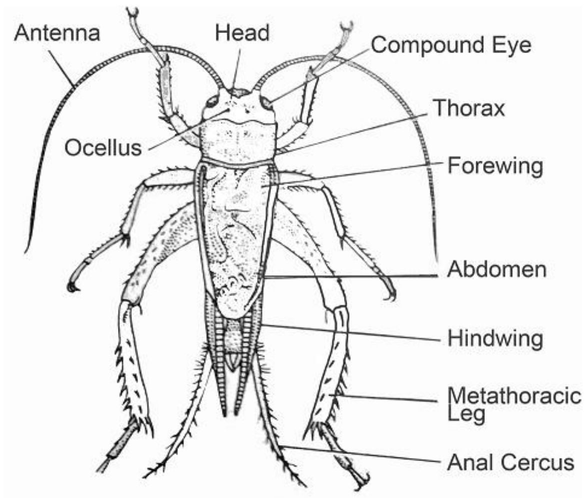


Fig.8.10 Gryllus

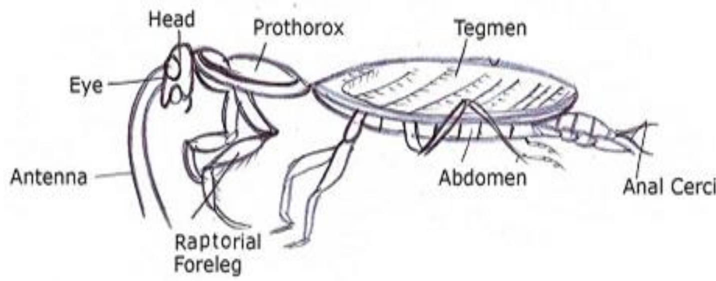


Fig 8.11Mantis

11.Mantis: *Mantis* is commonly called praying mantis.The colour of *Mantis* is usually green. It is a large insect (5-10cm), with a small triangular head, a long prothorax and abdomen consisting of 10-segments. Wings are folded flat and overlap the sides of the body. It is found in areas of green vegetation. It feed voraciously on other insects. Female eats up the male after copulation. The female lays about 200 eggs in frothy mass which soon hardens into a waterproof egg case.

12.Carausius: *Carausius* is commonly known as stick insect because it mimics a twig to escape enemies. *Carausius* is herbivorous and is found in tropical forests in thick vegetation. Body is elongated and slender and can be divided into head, thorax and abdomen. Head is small, bears a pair of antennae and a pair of small compound eyes. Thorax is elongated bearing pairs of long slender legs. Abdomen has 10 segments. Mouthparts are of chewing type. Sexes are separate. While male is small, winged and active, the female is large, sluggish and apterous.

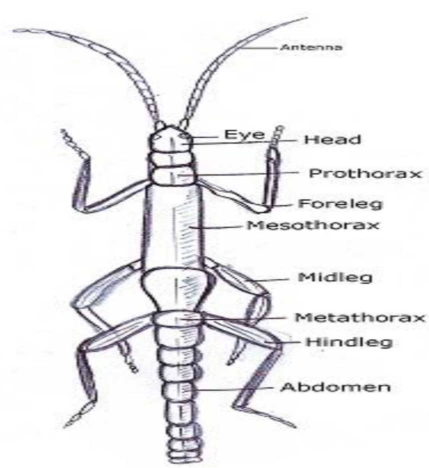


Fig.8.12 Carausius

8.4 Palaemon (*Macrobrachium malcolmsonii)*

The Indian Freshwater Prawn

Systematic position

Phylum Arthropoda

Subphylum Mandibulata

Class Crustacea

Subclass Malacostraca

Order Decapoda

Genus *Palaemon*

Species *malcolmsonii*

Habits and Habitat:-

Palaemon is commonly known as prawn. It is found in freshwater streams, ditches, lakes, ponds, rivers and reservoirs. It is a nocturnal animal hiding at the bottom during the day and coming to the surface at night in search of food. It is omnivorous, feeding on small organisms, like algae, minute insects, mosses, debris etc. It walks slowly at water bottom with the help of its 10 walking legs and swims actively to the surface with the help of its 10 pleopods.

8.4.1- STRUCTURE

External Morphology

1. Shape and size. Body of *Palaemon* is elongated, spindle shaped and bilaterally symmetrical. The size of *Palaemon* varies from species to species. *P. malcolmsonii* found in Bengal, Tamilnadu and Central India and measures about 30 cm, *P. carcinus* varies upto 90 cm in length while *P. lamarrei* measure only 2.5-5.0 cm in length.

2. Colour. *Palaemon* species are of pale-yellow and greenish color with brown tinge or with orange-red patches. Preserved specimens become deep orange-red.

3. Body Divisions. Body of adult prawn is distinctly divided into 19 segments, all bearing jointed appendages. The body can be divided into two regions:

(1) Anterior Cephalothorax

(2) Posterior Abdomen

1. Cephalothorax. Cephalothorax is a large, rigid, unjoited, immovable and cylindrical structure. It consists of 13 segments, 5 of the head region, and 8 of the thorax region, all bearing jointed appendages (kotpal).

2. Abdomen. Abdomen is rounded dorsally and compressed laterally and consists of 6 movable segments and a terminal conical structure, called telson. Each abdominal segment bears a pair of jointed appendages called pleopods or swimmerets (Fig. 12) (Rastogi, 2015).

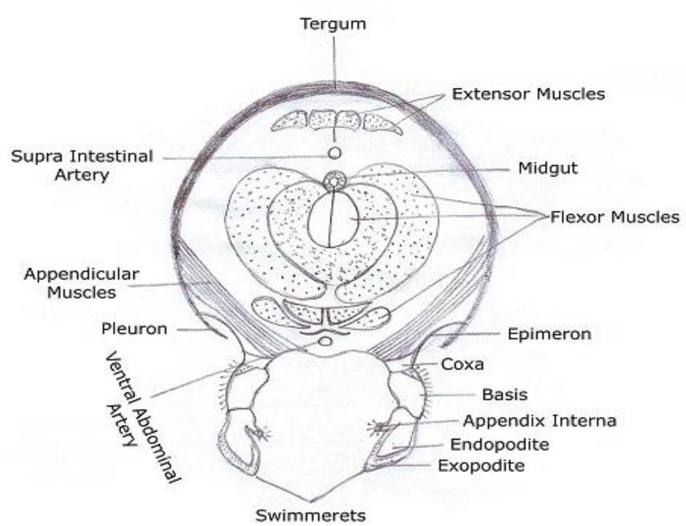


Fig. 12 ***Palaemon*** **T. S. Abdomen**

Fig 8.13Palaemon

4. **External Apertures**.

At the anterior end of cephalothorax is a mid-ventral slit-like aperture called mouth. Anus is a longitudinal aperture situated mid-ventrally at the base of telson. Renal apertures are paired apertures found on a papilla at the inner surface of coxa of antennae. Male genital apertures are present in male prawn on the inner surface of coxae of fifth pair of walking legs. Female genital apertures are present on the inner surface of coxa of third pair of walking legs. Openings of statocysts are present in the roof of precoxae of antennules. Body and appendages are covered by a hard protective calcareous shell or exoskeleton. Exoskeleton of arthropods is light-weight, tough and composed of structural polysaccharide called chitin. In *Palaemon*, each segment of body bears a pair of jointed appendages. Each appendage consists of a common base (or protopodite) bearing two rami - an inner or median endopodite and an outer exopodite. An appendage that is composed of two branches is known as biramous.

In prawn there are 19 pairs of appendages, 13 in cephalothorax and 6 in abdomen. Cephalothoracic appendages further include 5 pairs of anterior cephalic appendages and 8 pairs of posterior thoracic appendages.

(I) Cephalic Appendages: These are: (i) Antennules (ii) Antennae (iii) Mandibles (iv) Maxillulae and (v) Maxillae

1. Antennules: The antennules are attached, one on either side, below the base of eyes-stalks. The protopodite is three segmented due to the intervention of a large precoxa between coxa and the body.The precoxa is large and dorso-ventrally flattened and coxa is short and cylindrical.

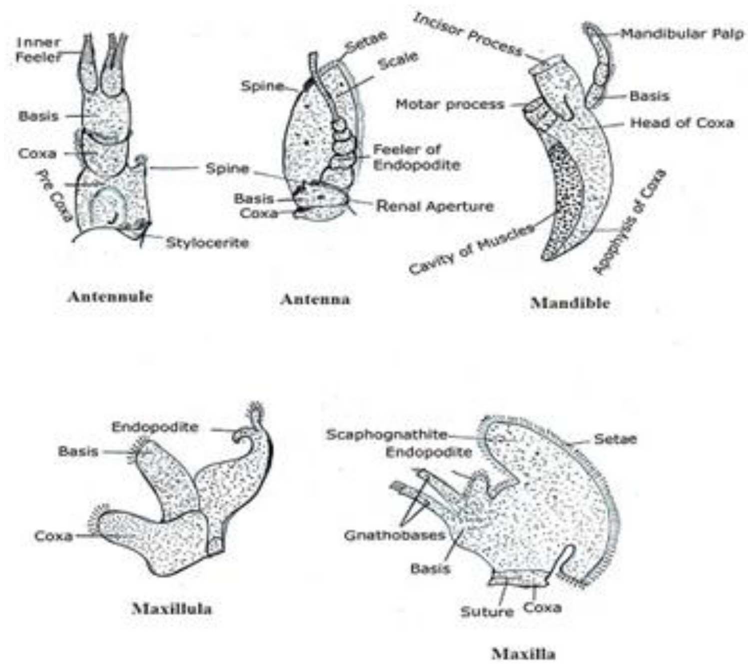


Fig 8.14Palaemon: cephalic appendages

2. Antennae: The antennae lie, one on either side, just below the antennules. It consists of a protopodite, endopodite and exopodite. The protopodite is small, two segmented and swollen due to presence of excretory organ inside. Endopodite is represented by a many-jointed sensory feeler, while exopodite is in the form of a broad and leaf-like plate, the squama or scale.The antennae are sensory, excretory and balancing organs.

3. Mandibles: The mandibles are short, stout and highly calcified structures situated in the 3rd segment one on either side of mouth. It is differentiated into a triangular, hollow and spoon-shaped proximal part and a solid distal part of head. The latter can be further distinguished into inner molar process with 5 or

6 teeth and an outer incisor process terminating in three denticles. Mandibles constitute the biting jaws and are masticatory in function.

4. Maxillulae: These are small, delicate, thin and leaf-like appendages. Endopodite forms a curved process bifurcated at the apex. The exopodite is absent. Maxillulae help in the manipulation of food.

5. Maxillae: The maxillae are thin and leaf-like mouth appendages. The endopodite is quite small, while exopodite forms a large expanded, fan-shaped scaphognathite. Maxillae help in respiration and in the manipulation of food.

(II) Thoracic appendages

There are 8 pairs of thoracic appendages. Anterior appendages consist of first 3 pairs of maxillipedes or foot jaws and posterior appendages consist of 5 pairs of paraeopods or walking legs (Fig. 14).

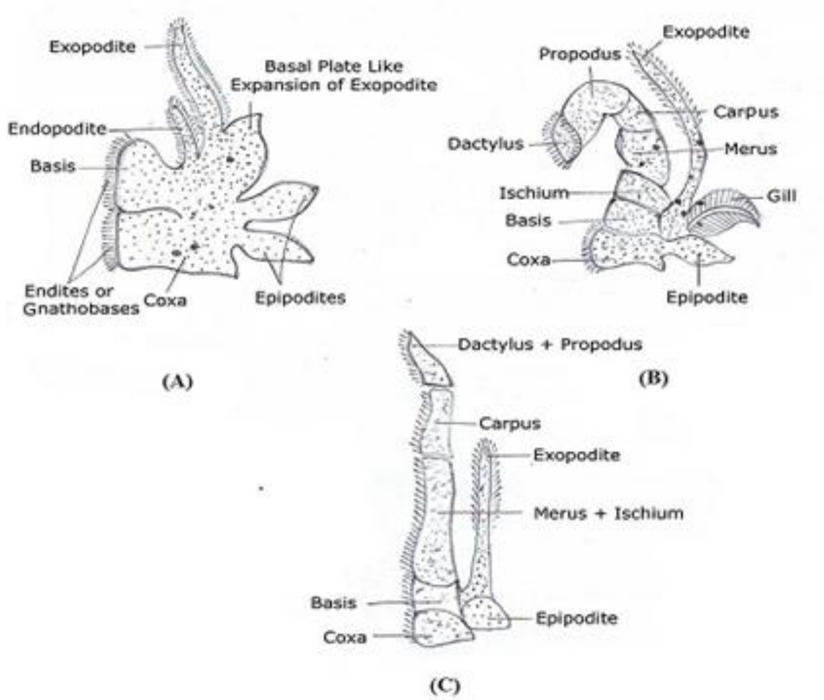


Fig.8.15 *First maxillipedes, Second maxillipedes, Third maxillipedes*

1. First maxillipedes. These are dorsoventrally flattened, thin, delicate, leaf-like structures present in first thoracic segment.The outer margin of coxa bears bilobed epipodite or the primitive gill. The basis carries a small endopodite and a long exopodite bearing setae along their whole length.

2. Second maxillipedes: Coxa bears an epipodite and a gill on its outer margin. The exopodite is unjointed and covered with setae but the endopodite is 5 segmented namely ischium, merus, carpus, propodus and dactylus. The last two podomeres are bent backwards and inwards and possess cutting margins.

3. Third maxillipedes: These are leg-like in appearance but possess same parts as 2nd maxillipedes. Outer border of coxa bears an epipodite. Basis supports a long, slender and unsegmented exopodite covered with setae and a 3-jointed endopodite. The first podomere represents fused ischium and merus, the 2nd carpus and the third represents fused propodus and dactylus.

4. Walking legs: The walking legs consist of a 2-segmented protopodite and 5-segmented endopodite. All the seven podomeres, namely the coxa, basis, ischium, merus, carpus, propodus and dactylus are arranged in a linear series and are movably hinged together. Unlike maxillipedes, they don't have any exopodite.

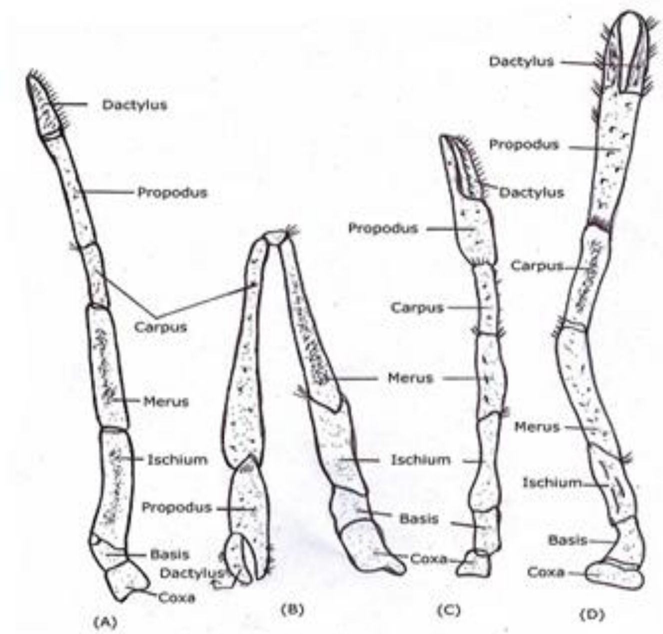


Fig.8.16

1st and 2nd pair of walking legs: These are known as chelate legs due to the prolongation of propodus beyond its articulation and with dactylus to form a pincer-like or forcep-like structure. These are used to grasp the food and pass it to mouth (Rastogi, 2015).

3rd, 4th, and 5th walking legs: These are typical nonchelate legs, 3rd pair of walking legs in female and 5th pair of walking legs in male bears the reproductive openings.

(III) Abdominal appendages

There are six pairs of abdominal appendages which are collectively known as pleopods or swimmerets. These help in swimming.

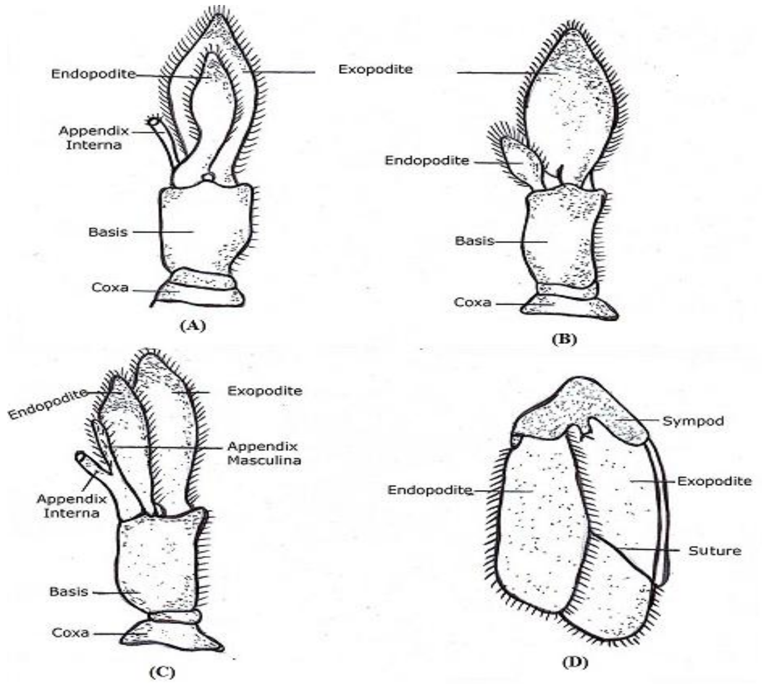


Fig. 16. ***Palaemon*. Abdominal appendages**
(A) Typical (B) First (C) Second of male (D) Uropod

1. First abdominal appendages: Endopodite is greatly reduced in size while appendix interna is absent.

2. Second abdominal appendages: The 2nd pair of pleopods of male possesses an additional rod-like process (appendix masculine) in between the appendix interna and endopodite. Second pleopod of female is typical.

3. Third, fourth and fifth abdominal appendages: In a typical appendage, like the 3rd, 4th or 5th pair, the protopodite consists of a ring-like coxa and a cylindrical basis. The basis bears flattened leaf-like smaller endopodite, and larger exopodite. Outer margin of basis and the free margins of exopodite and endopodite are fringed with setae.

4. Sixth abdominal appendages: The 6th pair of abdominal appendages is called uropods. These are large, stoutly built structures present one on either side of telson. The coxa and basis are fused into a triangular sympod, bearing the oar-shaped endopodite and exopodite. Exopodite is bigger than the endopodite and partially divided in the middle by a transverse suture.

Nervous system of *Palaemon*:

1. **Brain or supra-oesophageal ganglia:** It is situated beneath the base of rostrum, in front of the junction of oesophagus with the cardiac stomach. The following nerves originate from the brain.

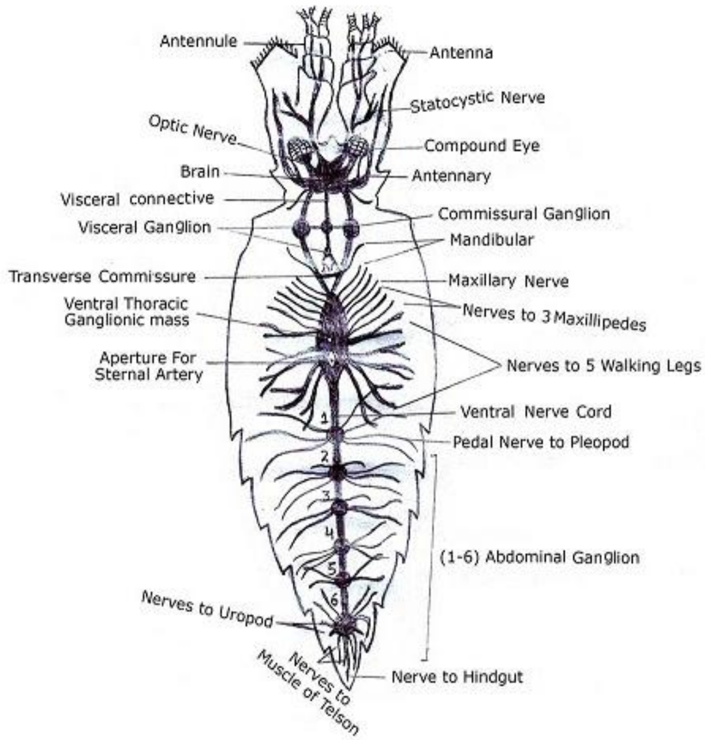


Fig. 8.18 Nervous system of *Palaemon* (prawn)

(I) Optic nerves: Optic nerves arise from the dorsal surface of the brain one on each side, and pass forwards and outwards in the eye stalks.

(II) Antennulary nerves: Antennulary nerves arising immediately behind and below the place of origin of optic nerves.

(III) Antennary nerves: Antennary nerves originate from the ventral surface of the brain. Each nerve runs obliquely downwards and forward to enter the base of antenna.

2. Circum-oesophageal commissures: Circum-oesophageal commissures arise from the hind end of the brain and run outwards and then downwards along the sides of the oesophagus and meet on the ventral side into suboesophageal ganglia which really form the anterior part of the extensive thoracic ganglionic mass. Each commissure presents a small commissural ganglion and a slender transverse commissure which connects the two circum-oesophageal commissures.

3. Ventral thoracic ganglionic mass: Ventral thoracic ganglionic mass is an elongated oval structure lying immediately above the thoracic sterna plates in the mid-ventral line. Following nerves originate from the ventral ganglionic mass:

(i) Mandibular nerves.
(ii) Maxillulary nerves.

(iii) Maxillary nerves.
(iv) Nerves to first, second and third maxillipedes.

(v) Neves to first, second, third, fourth and fifth pair of walking legs.

4. Ventral nerve cord: Ventral nerve cord lies in the mid-ventral line in the abdominal region. There are six abdominal ganglia which give nerves to appendages, muscles, uropods, telson and hindgut.

8.4.2- Reproductive system:-

The sexes are separate and sexual dimorphism is well marked.

1. The male is bigger in size than the female.

2. The abdomen of male is narrower than that of female.

3. The second chelate leg of male is longer, stronger and more spiny than one in female.

4. In male the second pleopod bears an additional process (appendix masculine) between endopodite and appendix interna.

5. The paired female reproductive apertures are situated on the inner side of coxa of 3rd pair of walking legs and the male genital apertures are situated on the coxae of 5th pair of walking legs.

6. In male, epimera of abdominal segments are smaller than that in female.

This external difference in the male and female organisms is called sexual dimorphism.

Male reproductive system:-

The male reproductive organs are:
1. Testis
2. Vasa differentia
3. Vesicula seminalis

1. Testis: The testis is two in number and is soft, white and elongated. They fuse at their anterior ends to form a common lobe. The testis enclose a central space or gap which gives way to the cardiopyloric strand connecting the heart to the cardiac stomach. The testis consists of a large number of coiled, narrow, thin-walled seminiferous tubules embedded in connective tissue. Each seminiferous tubule is lined by a single layer of germinal epithelium. Each tubule is lined with germinal epithelium, the cells of which undergo spermatogenesis to form spermatozoa. A mature sperm consists of a rounded cytoplasmic body, containing a large, dark, crescentic nucleus, and a tail-like blunt process.

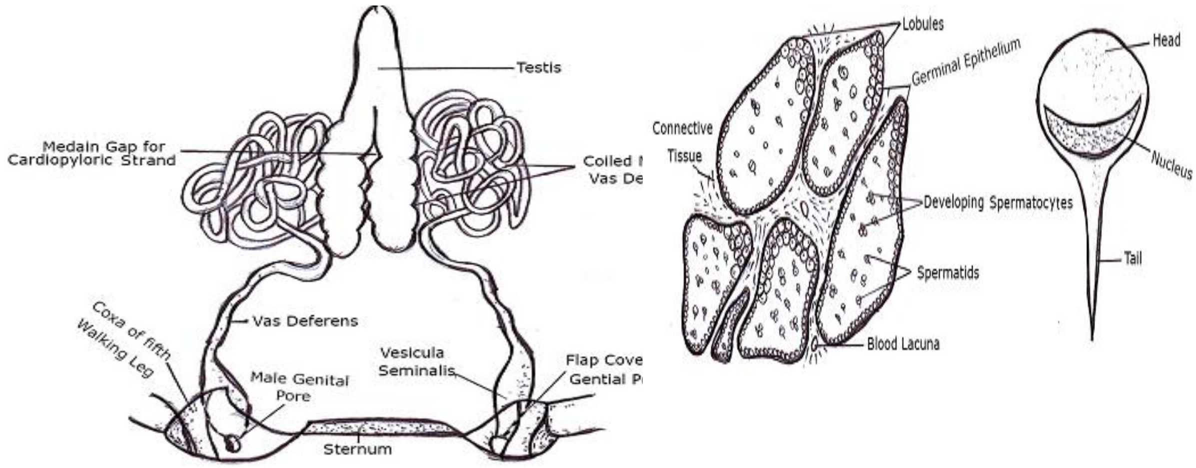


Fig. 8.19 Palaemon

(A) Male reproductive organs

(B) A portion of testis in section showing seminiferous tubules

(C) A sperm

2. Vas deferentia: Vasa deferentia are a long coiled and narrow tube; the vasa deferens arises from each testis near its posterior end. It is differentiated into two parts - the proximal highly convoluted part (which emerges out of the testis) and the distal straight part (which runs vertically downwards between the abdominal flexor muscles and the thoracic wall). Each vas deferens reaching ventrally near the base of 5^{th} leg swells to form a club-shaped vesicular seminalis.

3. Vesicula seminalis: The vesicular seminalis acts as on organ of storage and contains sperms in the form of bundles. Each vasicula seminalis opens to the exterior through male genital apertures situated on the inner side of coxa of 5^{th} walking leg of its side. The genital pore is protected by a flap of integument.

Female reproductive organs: The female reproductive organs are:

1. Ovaries: The two ovaries are white, compact and sickle-shaped bodies touching each other at both the ends but leaving a gap in the middle for the passage of the cardiopyloric strand. The size and shape of ovaries vary with age and the season of year. Each ovary consists of numerous rows of ova arranged radially and enclosed in a membranous capsule. Immature ova lie towards the centre while mature ova towards the surface of ovary (Kotpal). The ova are large nucleated cells with plentiful yolk contained as reserve food.

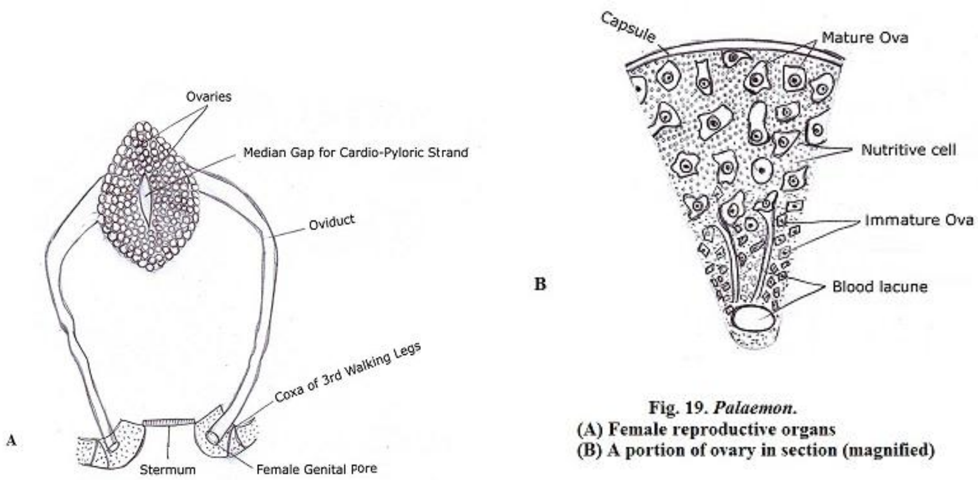


Fig. 19. ***Palaemon.***
(A) Female reproductive organs
(B) A portion of ovary in section (magnified)

Oviducts: From the middle of the outer surface of each ovary arises a short thin-walled tube known as oviduct. It opens outside through a female genital aperture on the inner side of the coxa of third walking leg of its side.

8.4.3- Life history and development:

1. Fertilization: Fertilization is external in *P. malcolmsonii.* It breeds during May, June and July. About two or three hundred mature eggs are laid by the female at one time in slimy stringe. The male deposits spermatophores near the genital opening of the female and the eggs get fertilized as they come out (Kotpal).

2. Development: Development is direct and the juveniles hatching out of the eggs resemble the adult except in size. The eggs hatch in 5 to 6 weeks and cling to the pleopods for some time. Prawns usually have a life span of 3 to 5 years.

8.5- Zoological importance of *Peripatus*

Peripatus belong to the phylum Onychophora (Gr., onyx=claw; pherein=to bear) and is considered to be a connecting link between Annelida and Arthropoda. *Peripatus* exhibits discontinuous distribution with its species scattered in most of the warmer parts of the world such as Australis, Africa, Central America, New Zealand, West Indies, Mexico, Malaya Archipelago and India. There are about 70 species in this phylum belonging to a few genera or possibly to one genus, *Peripatus*.

Habits and Habitat:

Peripatus is a terrestrial animal; living in moist places, in crevices of rocks, under stones, logs and bark and other dark and damp places where it is protected both from loss of water and also from the predatory arthropods. It is nocturnal in nature and predaceous and carnivorous in feeding habit.

External morphology:

Peripatus body is cylindrical, elongated and bilaterally symmetrical measuring 5-7 cm in length (Fig. 25). Outer covering or skin is velvety-like which is thrown into transverse wrinkles bearing numerous small papillae armed with spines. Head is not distinct. The anterior end bears a pair of antennae, a pair of simple eyes, a pair of jaws, and a pair of oral papillae. Mouth is ventral on the anterior side. Trunk bears a number of stumpy leg-like outgrowths (14-43 pairs) all along the length of the body (Fig. 26). There are unjointed and each one bears two claws. Anus lies at the posterior end of the body and behind the last pair of legs. Sexes are separate, fertilization is internal and the development is direct (Verma, 2015).

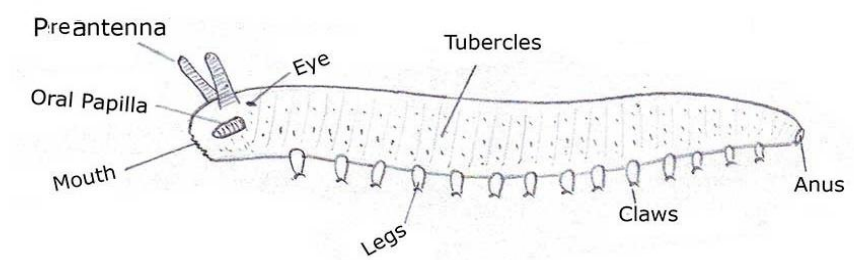


Fig. 25 ***Peripatus***

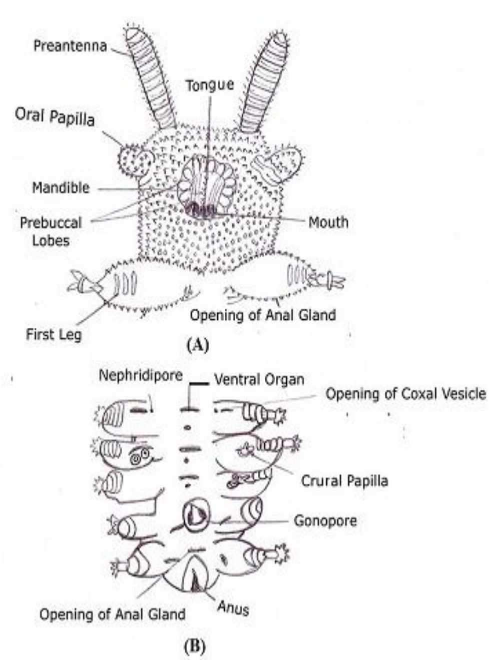


Fig. 26 *Peripatus* (A) Anterior end in ventral view (B) Posterior end in ventral view (C) A leg

Iternal morphology:

Body wall is dermomuscular and consists of cuticle, epidermis and dermis. Body cavity is in the form of haemocoel lined with epithelium. Mouth leads into alimentary canal via tongue (bearing sensory spines), pharynx, oesophagus, long stomach-intestine and a short rectum. Respiration happens via tracheae. Excretory organ consists of a pair of metanephridia containing ciliated funnel and nephrostome in each segment. Nervous system consists of a pair of suprapharyngeal ganglia or brain with two circumpharyngeal connectives and a pair of widely separated lateral longitudinal nerve cords connected together by transverse commissures. Ganglia on the cords are indistinct. Sensory organs are a pair of eyes near the base of antenna, taste spines on the lips and preoval cavity and tactile spines on the surface of tubercles. Female reproductive organs include a pair of ovaries, a pair of oviducts and a pair of uteri. The uteri join together to open outside through a common vaginal opening. The male reproductive organs have paired testes, seminal vesicles, vasa deferentia and genital opening.

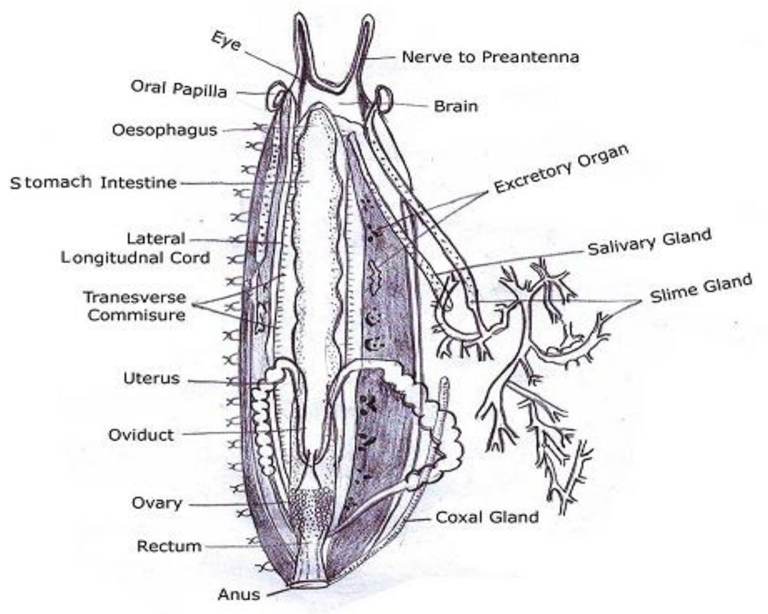


Fig. 27 ***Peripatus*** **Internal structures**

Affinities of *Peripatus*: Despite having no economic importance *Peripatus* is zoologically interesting because it exhibits both annelid and arthropod characteristics besides having peculiarities of its own.

Phyla characteristics those are similar to that of *Peripatus*:

(I) Annelidan characteristics:

1. Vermiform body and dermo-muscular body wall with underlying longitudinal muscles.

2. Absence of a true head.

3. Structure of the simple eyes as in polychaetes.

4. Legs are in the form of unjointed hollow stumpy outgrowths resembling to parapodia of annelids.

5. Locomotion happens via slow peristalsis as in earthworm.

6. Simple, straight alimentary canal with a terminal mouth and anus.

7. Presence of segmentally arranged nephridia.

8. Presence of cilia in the excretory and reproductive ducts.

(II) Arthopodan characteristics:

1. Cuticle has a thin deposit of chitin, like that of arthropods.

2. Presence of jaws, antennae, spines and claws.

3. Body cavity is haemocoel.

4. Locomotion by definite legs, having definite musculature and provided with claws.

5. Presence of a tracheal respiratory system.

6. Coelom reduced to small cavities and is present around the excretory and reproductive ducts.

7. Presence of modified nephridia.

8. Brain is large and typically arthropodan.

9. Reproductive organs and development is of arthropodan type.

Peripatus differs from other phyla in following ways:

(I) Onycophoran characteristics:

1. Body shows no or indistinct external segmentation.

2. Cuticle is rough and is covered with numerous velvety processes. These are not found in any other phyla.

3. Antennae not homologous to the antennae of other arthropods.

4. Three-segmented head of Peripatus shows a condition mid-way between that of annelid and arthropoda.

5. Eyes less complicated.

6. Single pair of jaws.

7. Non-jointed legs with claws.

8. Tracheal openings and irregular distribution of spiracles.

9. Ventral nerve cords widely separated and without ganglia.

10. Distribution of reproductive organs unique.

(II) Molluscan characteristics:

Peripatus was previously included with mollusca due to slug-like appearance of its body and ladder-like nervous system, as found in Amphineura and Prosobranchiata.

Taxonomic Position:

Onychophora have both annelidan and arthropodan characteristics. *Peripatus* is of great biological significance as it is regarded to be a connecting link between annelida and arthropoda. It appears to be more closely allied to arthropods than to annelids and arose as an offshoot from near the base of arthropod line.

Manton (1958) and other contemporary zoologists considered onychophora as a class of Arthropoda but others put it with annelids due to the absence of exoskeleton and jointed limbs, and due to the presence of certain annelidan characters. Strictly speaking *Peripatus* is neither an annelid nor arthropod, but has distinctive characteristics of its own. Therefore, onychophora is now-a-day treated as a separate phylum.

8.6- Mouth Parts of Insects

Insects feed on animals and plants in diverse ways and their mouthparts have become modified for those purposes. Important types of insect mouthparts can be described as follows:

Biting and chewing type: Biting-chewing mouthparts represent the most primivitve and unspecialised type which appeared in early insects in the course of evolution. This type of mouthpart is common among orthopteran insects such as grasshoppers, cockroaches and crickets (Fig. 20). Some other species like - termites, beetles, silver fish, earwigs, book lice, bird lice as well as some hymenoptera and many larval forms, specially the caterpillars of lepidoptera, falls under this category. This type of mouthparts consist of labrum (or upper lip), paired maxillae (first maxillae), labium (second maxillae), a pair of mandibles, epipharynx and hypopharynx. Maxillary palps act as sensory feelers to locate the food. Mandibles work by two set of muscles and masticate food with a teeth like process. *Ligula*, formed by paired and glossae paraglossae helps in pushing the food into pharynx.

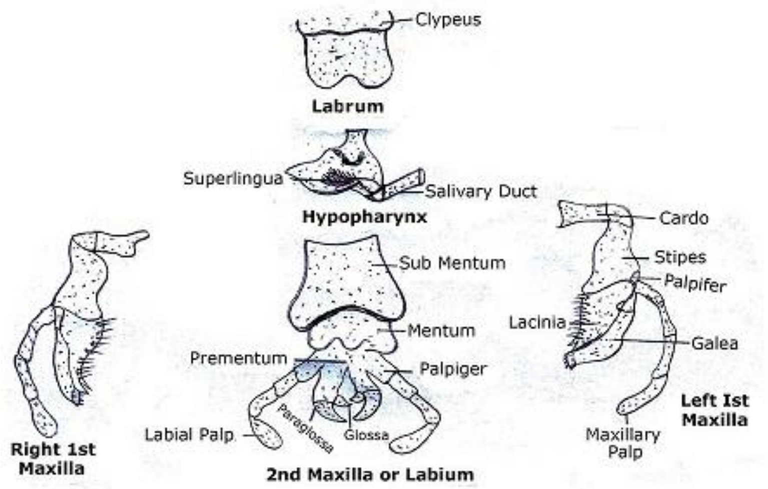


Fig. 20. Mouth parts of *Cockroach*

Piercing and sucking type: Piercing-sucking mouthparts are found in blood-sucking insects like mosquitoes, in bugs such as the bedbug and kissing bug, and in herbivorous insects such as aphids, which feed on plant juices. In this type the mandibles and maxillae resemble fine needles, meant for piercing the skin. Labium forms a hollow grooved channel which encloses these needles.

In mosquitoes the mouthparts consist of a long proboscis which has labium, forming an elongated, fleshy and mid-dorsally grooved tube. It encloses the needle-like stylets, formed by the modifications of the maxillae, mandibles and hypopharynx. Needle-like labrum is fused wih epipharynx and forms long covering of the open groove of proboscis. Two small labellae, at the tip of proboscis, are used as feelers and enables the mosquito to select appropriate part of its victim to attack. Mouthparts are well developed in female mosquitoes as they feed on blood.

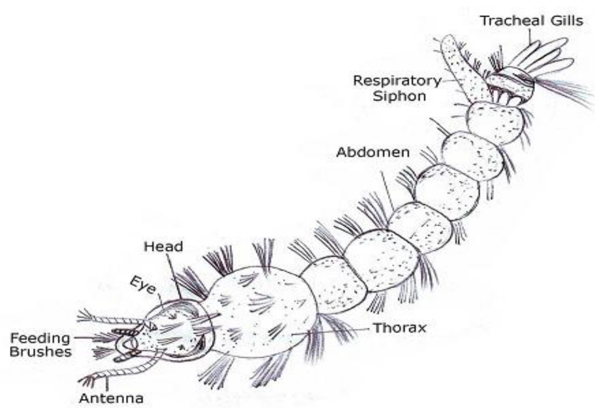


Fig. 21 Larva of *Culex*

Chewing and lapping type: Chewing-lapping mouthparts occur in honey-bees and bumble-bees. Such mouthpart consists of a long tongue, which is formed from the glossae of the labium, ending in a spoon-shaped labellum. A temporary food channel is formed by the proboscis, galeae and labial palps fitting together. Through this food channel the liquid food flows up, assisted by the pumping action of the pharynx. Mandible and labrum helps in chewing the food.

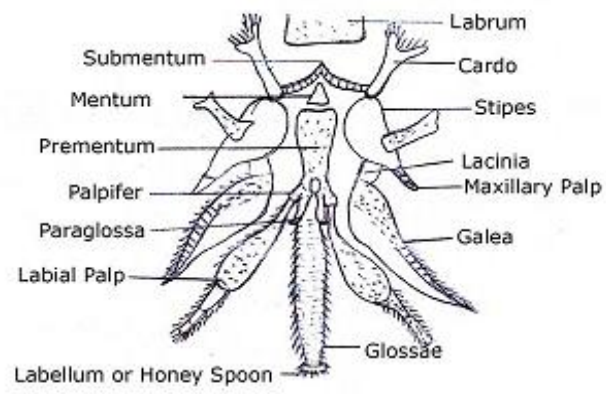


Fig. 22 Mouthparts of *Honeybee*

Sponging type: Sponging mouthparts are found in flies such as housefly. It helps in sucking up the liquified food. Flies having such mouthparts lack the cutting weapons of the insects that chew food. Mandibles are altogether absent, while the maxillae are represented only by two maxillary palps, each made of a single piece. Labium is greatly modified to form the so-called proboscis, which can be divided into three parts. (i) A proximal cone-like rostrum bearing the maxillary palps (ii) A middle haustellum with a mid-dorsal groove, serving as food passage and a ventral heart-shaped plate called theca (iii) A distal labellum consisting of two expanded lobes or labellae.

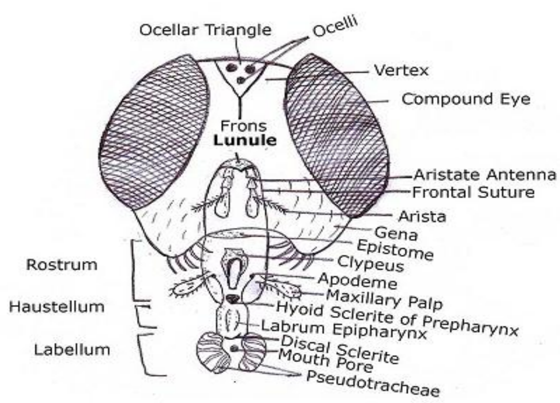


fig. 23 Head and mouthpart of housefly

Siphoning type: Siphoning type of mouthparts is found in butterflies and moths that feed on nectar. In such mouthparts the maxillae form the main proboscis and not the labium. Mandibles and labium are much reduced, the maxillary palps are rudimentary and labium forms a triangular plate bearing labial palps. Galeae are much coiled and elongated, each forming a half tube, which makes complete tube when both are locked together. When not in use the proboscis is coiled beneath the head and it uncoils (to reach the nectar) during feeding process. It is the rise in blood pressure which uncoils the proboscis.

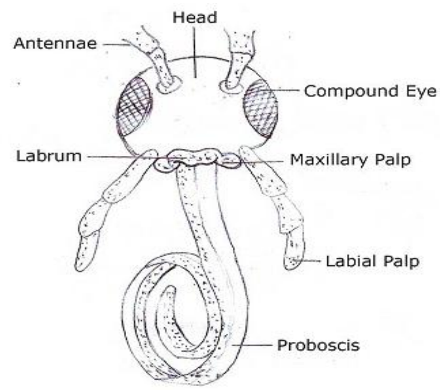


Fig. 24 Mouthparts of Butterfly

8.7- Social insects and their economic importance:

Social insects are any of the numerous species of insects that live in colonies and manifest three important characteristics – Group Integration, Division of labor & Overlap of Generations. Social insects, unlike the majority of insect species, live in organized groups. Social insects include wasps, bees, ants, termites etc. They reproduce cooperatively & share resources like food & shelter. These insects are differentiated into various castes based on their structure, function & behavior – like reproductives (e.g. Queen) and Steriles (e.g Workers and Soldier). Characteristically an insect society is formed of a parent or parents and a large number of offspring.

The individual members of the society are divided into groups, each having a specialized function and often exhibiting markedly different bodily structure. Some of the well known social insects are Gypsy moth (*Lymantria dispar dispar*- a pest of hardwood trees in North America), Corn earworm or cotton bollworm (*Helicoverpa zea* - a major agricultural pest), Indian meal Moth (*Plodia interpunctella* - a major pest of grain and flour), Codling moth (*Cydia pomonella* - a pest mostly of apple, pear and walnut trees), Light brown apple moth (*Epiphyas postvittana* - a highly polyphagous pest), Silkworm (*Bombyx mori* - for its silk), Wax moths (*Galleria mellonella*, *Achroia grisella* - pests of bee hives).

Social insects are among the most dominant and prolific of all organisms on earth. Social Insects are an important factor of the eco-system as well. The Social Insects are known to eat debris and left-over food so that the earth is not inundated with waste products As social insect groups grow, they evolve more differentiation between members but reintegrate into a more closely organized system known as eusocial. These are the most advanced societies with individual polymorphism, and they contain insects of various

ages, sizes, and shapes. All the eusocial insects are included in the orders Isoptera (termites) and Hymenoptera (wasps, bees, and ants) (Wikipedia).

Termites:-

Termites belong to the order Isoptera and are eusocial insects. Termites are sometimes called white ants. They may resemble ants in size, but ants have a narrow waist and elbowed antennae while termites have a thick waist and antennae that resemble a string of beads. Ecologically, termites play an important role in the environment by helping to break down and recycle dead wood and other plant tissues. They become pests when their appetite for wood and wood products extends to human homes, fence posts, building materials, cardboard, and other valuable products. In tropical and subtropical forests where termites are abundant, railroads must use expensive metal ties because wooden ones are quickly destroyed.

The termites feed primarily on the cellulose and lignin found in plant cell walls; these compounds are the main ingredients of wood and all paper products. Termites cannot digest the cellulose directly so they rely upon symbiotic bacteria and protozoa living within their intestines to supply most of the enzymes needed for cellulose digestion.

The Termite Caste System: The termites live in a nest or colony of hundred, thousand, or even million. The colony consists of various groups of individuals having different functional roles according to a "caste system".

The worker caste is the largest group. They are blind and white in appearance. They navigate with their antennae rather than their eyes. These soft-bodied, wingless individuals perform all of the hard labor in the colony: they clean, maintain, and repair the nest, gather food and water and care for the young. They construct new tunnels and galleries using mud, saliva and faeces. Some of them may become soldiers or reproductives, but most will spend their entire lives as workers. Members of **the soldier caste** are larger in size but fewer in number than the workers. They are also wingless, but they have large heads with powerful jaws. They are pale yellow brown in color & have enlarged head & mandibles. Their enlarged jaws prevent them from feeding themselves and they rely upon workers to assist them in this task. Their job is to guard the nest site and protect it from attacks by ants or other invaders. In some species they have a large gland in the head that shoots defensive chemicals through a nozzle at the front of the head.

The reproductive caste always includes a king (male) and a queen (female) who are the parents of the termite family and founders of the colony. These are the only adult insects in the colony. The queen lays large numbers of eggs which develop into more workers and soldiers as the family grows. Large colonies with multiple reproductives may split into two or more daughter colonies, a process known as "budding". Termite queens have the longest lifespan of any insect in the world, with some queens living up to 50 years.

The termite's caste system is regulated by pheromones. Pheromones regulate how many members of each termite cast are produced or may regulate workers from becoming reproductive. More than 2000 different species of termites are known. These can be divided into two groups: those that live entirely within wood, and more advanced species that live in tunnel and nest in the soil. The primitive species often have specialized habitat requirements, nesting only in rotten, damp, or dry woods. Their colonies are rather small and persist only as long as the food resource lasts. All wood-dwelling termites produce distinctive waste pellets which are often the first sign of an active infestation. In contrast, the subterranean termites construct underground nests and have the ability to tunnel through the soil to find new food resources. Termites are a delicacy in the diet of some human cultures and are used in many traditional medicines. Several hundred species can cause serious damage to buildings, crops or forest plantations thereby incurring economic losses.

Ants:-

Ants are common insects with some unique capabilities. There are more than 10,000 species of ants in the family Formicidae -- all of them are eusocial. There are more species of ants than all other social insects combined. They are also the most ecologically diverse group in terms of distribution, life history, feeding strategies, and specialized adaptations. Like all insects, Ants have three distinct body parts – head, thorax & abdomen.

Ants are the most ecologically diverse of all social insects. The following list includes some of the more common groups.

• Harvester Ants usually live in arid environments and feed primarily on seeds. Many species build elaborate underground nests that may reach depths of six feet or more.

• Army ants are nomadic predators that do not have permanent nests. They include legionary ants which live in South America, and driver ants which live in Africa.

• Slave-maker ants raid the colonies of other species and steal worker larvae and pupae. Once the slaves mature, they work for their "owners" until they die.

• Leafcutter ants (also known as parasol ants) are gardeners. They chew up plant leaves into a pulp and use it to fertilize a fungus they grow for food in underground gardens.

• Weaver ants build nests in trees. Workers interlink their bodies, pull branches into position, and tie the leaves together with silk spun by their larvae.

• Honey-pot ants feed on honeydew excreted by aphids. Some workers engorge themselves with food reserves until their abdomens swell to the size of marbles.

• Fire ants are an invasive species with a very painful sting. They respond aggressively to any disturbance of their nest.

• Thief ants are very small. They raid the food supplies of larger ants and then escape through tunnels that are too small for the bigger ants to enter.

• Carpenter ants build their nests in wood. Unlike termites, they do not eat the wood but they may still cause serious damage to homes and other wooden structures.

Ants are social insects & are divided into three castes – Workers, Males & Queens. Workers are sterile, wingless females. Males are almost same sized as workers, winged and have a small head with proportionally large eyes. Their sole purpose is to mate with the new queens and they die shortly after mating. Queens are largest members of the colony, often 2-3 times larger than workers. Queens can live for very large number of years.

Regulation of caste in ants is not well-understood. Apparently, all female eggs are identical when laid. Whether they mature into minors, majors, soldiers, or new queens depends on the care and feeding they receive as they grow and mature.

Bees :-

Bees are flying insects and close relative of wasp and ants. A vast majority of these species are solitary and do not produce honey. One of the most important species of bees is honey bee, *Apis melifera.* Bees exhibit complete metamorphosis. The young and the adults look very different and have different diets also. The bee life stages are egg larva, pupa and adult. Bee castes consist of workers (sterile females), drones (fertile males) and queen. Workers have a typical life span of a month and are responsible for collecting the nectar. Unlike workers drones can't fly and don't gather food from the colony. The role of the drones is largely to fertilize new queens and die immediately afterwards. Drones typically live for about 50 days. Queens can be distinguished from others due to their large size. Queens have the longest life span of all the bees within the hive. Their major role is to lay eggs. A queen controls the social organization within her colony by means of a pheromone secreted from her mandibular glands. A typical honey bee colony consists of tens of thousands of sterile workers and hundreds of drones and only a single queen.

Some bees collect nectar and then convert it into honey. This process occurs in the bee's crop where sucrose in the nectar undergoes enzymatic conversion into glucose and fructose. The honey is regurgitated for storage or mixed with pollen and fed to developing larvae. Some bees have abdominal glands that secrete wax. This wax, alone or mixed with other substances, is often used for construction of the nest site. Several bee products are economically significant the two most significantly used around the world are honey and wax. Honey is used in many ways by man also as the chief source of natural sweet in preparing candies, cakes and bread, jellies, jams etc. It forms a very important food for patients of diabetes or for persons undergoing very strenuous physical exertion. Bee wax is made of secretion of worker bees' abdominal glands. It is a product of industrial importance. It is used in the manufacture of many items including cosmetics, lotions, ointments, face cream, shaving cream, toothpaste, carbon papers, pencils, protective coating, ink, candles, plasters, paints, furniture-polishes, boot-polishes and electric goods. It is also used in model and mould making and in printing industry.

The honey bee communicates the location of nectar bearing flowers to its co-worker by using special form of dance language. It begins by regurgitating and distributing nectar to bees waiting in the hive. Once her generosity has garnered an audience, the dancing begins. There are two types of bee dances: the round dance and the tail-wagging or waggle dance, with a transitional form known as the sickle dance. The round dance is used for food sources around 100 meters away from the hive or closer. In this dance form the bee distributes some nectar to its co-workers in the hive and begin running in a small circles, switching direction every so often. After the dance ends, food is again distributed and the dance may be repeated three or more times. As the food source becomes more distant the round dance is replaced by the waggle dance. The waggle dance is performed by bees foraging at food sources that are more than 100 meters from the hive. This dance, unlike the round dance, communicates both distance and direction. A bee that performs a waggle dance runs straight ahead for a short distance, returns in a semicircle to the starting point, runs again through the straight course, then makes a semicircle in the opposite direction to complete a full figure-eight circuit. The duration of the straight run, measured in seconds, is an indicator of the distance of the food source. The orientation of the dancing bee during the straight portion of her dance indicates the location of food source relative to Sun.

Wasps :-

A wasp is any insect (that is neither a bee nor an ant) of the order Hymenoptera and suborder Apocrita. Eusocial behavior among wasps is found only in certain members of the family Vespidae. This means that wasps are paraphyletic with respect to bees and ants, and that all three groups are descended from a common ancestor. Wasps are a diverse group, estimated at over a hundred thousand described species around the world, and a great many more as yet undescribed. Insects known as wasps include the sawflies, the parasitic wasps and the stinging wasps. Wasps are characterized by two pair of membranous wings and an ovipositor. Wasps have a complete metamorphosis with four stages in their life history: egg, larva, pupa, and adult. There are males and females of most species of wasps. However as with most species in the order Hymenoptera, males are normally produced from non-fertilized eggs in a developmental process known as parthenogenesis. Female wasps develop from fertilized eggs and are usually much more abundant than males. In some species, male wasps are not even known to occur (Wikipedia).

Although some wasps are solitary, i.e. just one adult female per nest, most live a social life. Solitary wasps are relatively small insects that build their nests in burrows in the ground or out of mud on an exposed surface. The nest is then provisioned with an insect or spider that has been paralyzed by stinging and upon which one or more eggs are laid. The prey serves as a living but immobile food for the developing larvae of the wasp. Although quite small, parasitic wasps can be rather abundant, and they can exert a substantial measure of control over the populations of their prey species.

In contrast, the social wasps are relatively large insects that live in colonies of various sizes. These wasps develop colonies with three castes: workers, drones and queens. Workers are infertile females that do the labour & protect their colonies from invaders using their stings. The drones are relatively short-lived fertile males and serve only to fertilize the queens. The queens are long-lived wasps, and their major function is to initiate a colony and then spend their life laying eggs. Once a colony is established, the eggs and young are tended by workers which are non-fertile female wasps that can be very numerous in large colonies. Social wasps cooperatively feed their developing young on a continuous basis, often with chewed-up insects and other animal-derived foods.

They can be divided into three groups:

• **Yellow Jackets**: They usually build nests in underground cavities, such as old rodent burrows.

• **Hornets:** Nests are always located above ground. Some species colonize hollow trees while others hang brood comb from a tree branch and surround it with paper walls for protection against the weather and natural enemies.

• **Common Paper Wasps:** Nests are typically found under sheltered overhangs where they are protected from wind and rain. Their colony could be as big as 100 wasps living together in a nest.

Wasps have a great economic value. They help control arthropod pests by preying on them thereby reducing use of pesticides. While yellow Jackets feed on dead insects, the Paper & Hornet wasps provide great pest control services by preying on live insects. Wasps are an important source of pollination of figs too.

8.10.1- Long Answer type questions:

1. To describe the classification of arthropoda?
2. What is the economic importance of social insects?
3. What is the zoological importance of *Peripatus*?
4. Describe the mouth parts of insects?
5. Discuss the reproduction of *Palaemon*?
6. Write about the nervous system of *Palaemon*?

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UNIT 9:- PHYLUM MOLLUSCA

9.1 OBJECTIVES

1. The objective of this chapter is to understand the division of mollusca into different classes.
2. To understand different body parts and their functioning.
3. Detailed study of some important molluscs.
4. Understading habitat of *Pila*.
5. Understanding the nervous system and reproductive system of *Pila*.

9.2 INTRODUCTION

Phylum mollusca (L., molluscus, soft) includes soft-bodied invertebrate animals such as Octopods, snails, slugs, mussels, clams, oysters, tusk-shells, squids etc. The term mollusca were coined by Johnston. It is a diverse and widespread group, with about 112,000 species. Molluscs are the largest marine phylum, comprising about 23% of all the named marine organisms. Molluscs may be terrestrial or aquatic (freshwater or marine). They are found in all habitats - deserts, forests, lakes, rivers, abysses of sea, coral reefs, underground or even as parasite in the body of other animals. They may be found clinging to the rocks, crawling, and swimming, burrowing or even digging. They have diversified feeding habit and can be herbivores, carnivores or omnivores. They vary in size from giant squids (nearly 2m long) to little snails, a millimeter long. The largest of the molluscan classes is Gastropoda, which is represented by about 35,000 living and some 15,000 fossil species.

The three most universal features defining molluscs are - a mantle with a significant cavity used for breathing and excretion, the presence of a radula, and the structure of the nervous system. The "generalized" mollusc's feeding system consists of a rasping "tongue", the radula, and a complex digestive system. Although molluscs are coelomates, the coelom tends to be small, and the main body cavity is a hemocoel through which blood circulates; their circulatory systems are mainly open. The generalized mollusc has two paired nerve cords, or three in bivalves. Most molluscs have eyes, and all have sensors to detect chemicals, vibrations, and touch. The simplest type of molluscan reproductive system relies on external fertilization, but more complex variations occur. All produce eggs, from which may emerge trochophore larvae, more complex veliger larvae, or miniature adults.

Molluscan shells have always been economically important, having served as money in early days. They have been used in jewellery and buttons. *Octopus*, Scallops, oysters and squids are important food items. The scientific study of molluscs is called malacology.

9.3 GENERAL CHARACTERS AND CLASSIFICATION

9.3.1 General characters:-

1. Molluscs are essentially aquatic, mostly marine, few freshwater and some terrestrial animals.
2. Body is soft, bilaterally symmetrical, unsegmented and without jointed appendages.
3. Body can be divided into head, mantle, visceral mass and foot.
4. Body is commonly protected by an exoskeletal calcareous shell of one or more pieces, secreted by the mantle.
5. The head carries mouth, eyes and tentacles.
6. The mantle is a thick, muscular fold of body wall extended over the viscera and thus enclosing a space, the mantle cavity.
7. Visceral mass contains the visceral organs of the body in a compact form.
8. The foot is ventral in position and is usually thick and muscular being variously modified for creeping, ploughing and seizing but is absent in oysters.
9. Body cavity is haemocoel. The true coelom is generally limited to the pericardial cavity and the lumen of the gonads and nephridia.
10. Digestive system is complete. Digestive glands are liver or hepatopancreas. Radula is mostly present.
11. Circulatory system is closed type. Heart has one or two auricles and one ventricle.
12. Respiration direct or by gills or lungs or both. The respiratory pigment is haemocyanin.
13. Excretion is performed by nephridia or kidneys.
14. Nervous system consists of paired cerebral, pleural, pedal and visceral ganglia joined by longitudinal and transverse connectives and nerves.
15. Sexes are separating (dioecious) but some are hermaphrodita. Fertilization happens externally as well as internally.
16. Development is either direct or with metamorphosis through the trochophore stage called veliger larva.

9.3.2 CLASSIFICATION:-

Molluscs are classified into six classes according to their symmetry and also according to their food habits, shell, mantle, gill, nervous system, muscles and radula.

Class1. Monoplacophora (Gr., monos = one + plax = plate + pherein = bearing)

1. Body is bilaterally symmetrical and segmented. Mantle is dome shaped.
2. Shell is flattened and limpet-shaped with spirally coiled protoconch.
3. Foot is broad, flat and bears 8 pairs of pedal retractor muscles.
4. Five pair of gills which are in pallial grooves.
5. There are six pairs of nephridia out of which two are modified into gonoducts.
6. Intestine is highly coiled. Radula present in radular sac.
7. Heart consists of two pairs of auricles and a single ventricle.
8. Nervous system with longitudinal, pallial and pedal cords.

Examples: *Neopilina galatheae*.

Class 2. Amphineura (Gr., amphi = both + neuron = nerve)

1. Body elongated with reduced head.
2. Radula is present.
3. Shell as 8 dorsal plates or as spicules.
4. Foot is ventral, flat, large, and muscular.
5. Fertilization is external. Development happens via intermediate stage of trochophore larva.
6. Organisms are marine.

Subclass 1. Aplacophora

1. Body worm-like without shell and foot.
2. Radula is simple.
3. Calcareous spicules buried in cuticle.
4. A pair of bivalve ctenidia is present.

Examples: *Chaetoderma*, *Neomenia*, *Nematomerina*.

Subclass 2. Polyplacophora

1. Body is dorso-ventrally flattened; head small and without eyes and tentacles. Radulla, mantle, foot and external gills present.
2. Mantle cavity is present towards the back side.
3. Shell is in the form of 8 calcareous plates.

Order 1. Lepidopleurina

1. Shell valve are without plates.

2. Ctenidia few and posterior.

Examples: *Lepidopleurus*.

Order 2. Chitonida

1. Shell valve are with plates.

2. Gills along whole length of mantle groove.

Examples: *Chiton*, *Chaetopleura*, *Ischnochiton*.

Class 3. Scaphopoda (Gr., scapha = boat + podos = foot)

1. Exclusively marine.

2. Body bilaterally symmetrical, elongated and enclosed in a tusk-like shell open at both ends.

3. Head and eyes absent; mouth with tentacles.

4. Foot conical; radula present.

5. Kidneys are paired. Gonad is single.

6. Heart rudimentary.

7. Sexes are separate. Development includes trochophore larva.

Examples: *Dentalium*, *Pulsellum*, *Cadulus*.

Class 4. Gastropoda (Gr., gaster = belly + podos = foot)

1. Mostly marine, some freshwater, terrestrial, and few parasitic on echinoderms.

2. Includes snails and slugs.

3. Body unsegmented, asymmetrical and typically with a univalve, spirally coiled shell.

4. Head well developed and possesses eyes and tentacles.

5. Foot is large and flat.

Subclass 1. Prosobranchia

1. Mostly marine, few freshwater and terrestrial.
2. Body mass torted; head with a single pair of tentacles.

3. Shell closed by operculum.

4. Head distinct with snout bearing a pair of tentacles and a pair of eyes.

5. Foot is muscular and forms ventral part of the body.

6. Sexes are separate, gonad single, larva trochophore or veliger.

Order 1. Archaeogastropoda

1. One or two bipectinate internal gills.

2. Two kidneys and heart with two auricles.

3. Shell usually coiled.

4. Nervous system not concentrated usually with pedal cords.

5. Sexes are separate. Fertilization is external.

Examples: *Patella* (limpet), *Trochus* (top shell), *Fissurella* (key-hole limpet).

Order 2. Mesogastropoda

1. Mostly marine, some freshwater.

2. One auricle, one kidney and one mono-pectinate ctenidium.

3. Radula taenioglossate type having 7 teeth in each row.

4. Single osphradium.

5. Nervous system without pedal cords.

6. Fertilization is internal; larva is a free-swimming veliger.

Examples: *Pila* (apple snail), *Crepidula* (slipper shell), *Natica* (star shell), *Cypraea* (cowrie).

Order 3. Neogastropoda

1. Shell with more or less elongated siphonal canal.

2. Nervous system concentrated.

3. Free- swimming veliger suppressed.

Examples: *Murex*, *Magilus*, *Buccinum*, *Melongena*, *Conus*, *Oliva*.

Subclass 2. Opisthobranchia

1. Exclusively marine gastropods.

2. Shell small, without operculum or no shell.

3. Body mass torted or detorted.

4. Gills posterior to heart.

5. One auricle, one kidney and one gonad.

6. Nervous system without pleuro-visceral loop.

7. Hermaphrodite, i.e., sexes united.

Order 1. Cephalaspidea

1. Shell moderately developed.

2. Parapodial lobes present or absent.

3. Head with tentacular shield.

Examples: *Acteon*, *Hydatina*, *Bulla*.

Order 2. Anaspidea

1. Found mostly in tropical and subtropical waters.

2. Shell reduced or internal.

3. Well developed parapodial lobes.

4. Head with a pair of rhinophores.

Examples: *Aplysia* (sea-hare), *Akera*.

Order 3. Pteropoda

1. Pelagic snails with or without shell.

2. Shell reduced or internal.

3. Parapodial lobes well developed.

4. Head with a pair of rhinophores.

Examples: *Corolla*, *Clione*, *Cavolina*.

Order 4. Sacoglossa

1. Shell present or absent.

2. Pharynx suctorial.

3. Sperm duct is closed.

4. Parapodia and cerata present.

Examples: *Elysia*, *Oxynoe*.

Order 5. Acochlidiaceae

1. Minute without shell (naked snail).

2. Found in coarse sand.

3. Visceral mass separated from foot and covered with spicules.

Examples: *Acochlidium*, *Unela*.

Order 6. Notaspidea

1. Shell internal, external or reduced.

2. Mantle present but mantle cavity absent.

3. Gills bipectinate and osphradium on the right side.

Examples: *Tylodina*, *Pleurobranchus*.

Order 7. Nudibranchia

1. Shell absent.

2. Mantle or mantle cavity absent.

3. Internal gills and osphradium are absent.

4. Presence of dorsal outgrowths.

Examples: *Doris, Aeolis*.

Order 8. Pyramidellacea

1. Shell spirally twisted.

2. Proboscis long, operculum present but gill and radula absent.

3. Semi-parasitic forms.

Examples: *Pyramidella.*

Order 9. Philinoglossacea

1. Minute naked snails.

2. Head appendages and gills absent.

3. Visceral mass separated from foot only by a groove.

Examples: *Philinoglossa, Sapha*.

Order 10. Rhodopacea

1. Vermiform snails.

2. No external appendages.

3. Anus on right side of body.

Examples: *Rhodope.*

Order 11. Onchidiacea

1. Slug-like, naked or without shell opisthobranchs.

2. Pulmonary sac, anus and female gonopore located at the posterior end.

3. Male gonopore placed anteriorly.

Examples: *Onchidella*, *Onchidium*.

Order 12. Parasita

1. Endoparasitic gastropods found in the interior of holothurians.

2. Shelled embryos.

Examples: *Thyonicola*, *Entoconcha*.

Subphylum 3. Pulmonata

1. Mostly freshwater or terrestrial, a few are marine.

2. Detorted body mass.

3. Shell spiral or reduced or absent.

4. Mantle cavity or pulmonary sac with a pore on right side anteriorly.

5. Hermaphrodites.

Order 1. Basommatophora

1. Freshwater or brackish water and marine.

2. One pair of tentacles that is non-invaginable.

3. Eyes at tentacular bases.

4. Separate male and female gonopores.

Examples: *Lymnaea*, *Siphonaria*, *Planorbis*.

Order 2. Stylommatophora

1. Terrestrial pulmonates.

2. Two pairs of tentacles those are invaginable.

3. Second pair of tentacles with eyes at their tips.

4. Male and female gonopores are usually united.

Examples: *Limax*, *Partula*, *Helix* (land snail), *Retinella*.

Class 5. Pelecypoda (Gr., pelekus = batchet + podos = foot)

1. Aquatic, mostly marine, some freshwater forms.

2. Body bilaterally symmetrical and laterally compressed.

3. Head, tentacles, eyes, jaws as well as radulla absent.

4. Foot hatchet-shaped and extending between mantle lobes.

5. Gills or ctenidia are paired, one on each side.

6. Dioecious, veliger or glochidium larve in the life-history.

Order 1. Protobranchia

1. Gill filaments not folded.

2. Mouth placed at the base of proboscides.

3. Style sac is present in the stomach.

Examples: *Nuculina*, *Nucula*, *Yoldia*, *Malletia*.

Order 2. Filibranchia

1. Gill filaments incompletely fused.

2. Chitinous gastric shield in stomach developed.

3. Foot is small or poorly developed.

4. Style sac with crystalline style.

Examples: *Mytilus* (mussel), *Ostrea*, *Pecten* (scallop), *Spondylus* (edible oyster).

Order 3. Eulamellibranchia

1. Gills are firm and basket-like and help in gathering food.

2. Gill filaments fused completely to form tissue sheets.

Examples: *Unio*, *Teredo* (ship-worm), *Anodonta*, *Lamellidens*, *Enis*.

Order 4. Septibranchia

1. Marine forms.

2. Gills absent.

3. Stomach lined by chitin; style-sac reduced.

Examples: *Poromya*, *Cuspidaria*.

Class 6. Cephalopoda (Gr., kephale = head + podos = foot)

1. Exclusively marine.

2. Body dorso-ventrally elongated.

3. Shell internal, external or absent.

4. Head bears large eyes and mouth.

5. Foot modified into tentacles and siphon.

6. Dioecious; development meroblastic without metamorphosis.

Subclass 1. Nautiloidea

1. Shell external, coiled or straight.

2. Tentacles without suckers.

3. Two pair of gills and that of nephridia present.

Examples: *Nautilus*.

Subclass 2. Smmonoidea

1. Extinct.

2. Shell external and coiled.

Examples: *Pachydiscus*.

Subclass 3. Coeloidea

1. Shell internal or absent.

2. Tentacles few and with suckers.

3. One pair of gills and that of nephridia present.

Order 1. Decapoda

1. Ten arms present. Two are long and act as tentacles while rests of the arms are short.

Examples: *Sepia* (cuttle-fish), *Loligo* (squid), *Spirula* (spiral shell).

Order 2. Octopoda

1. Body globular and without fins.

2. Eight equal arms.

Examples: *Octopus*, *Argonauta*.

SOME EXAMPLES OF MOLLUSCA:-

1. *Octopus*: An *Octopus* (Commonly called devil fish) is a cephalopod mollusc of the order Octopoda. This nocturnal marine creature inhabits many diverse regions of the ocean, including coral reefs, pelagic waters and the ocean floor. It is generally found on the Pacific and Atlantic coasts. Around 300 species are recognized, which is over one-third of the total number of known cephalopod species. *Octopuses* are among the most intelligent and behaviorally flexible of all invertebrates. Humans in many cultures eat *Octopus*.

The body is unsegmented, symmetrical and soft bodied animals. Variations can be found in body parts based on species and/or geography. The head bears a pair of eyes. The mouth is surrounded by eight elongated equal arms webbed at the base and each arm bears suckers arranged in two rows. *Octopus* crawls on the ground and is able to change its color according to the background. The food is captured by the arms and is broken by radula and a pair of jaws. *Octopus* ejects ink from the ink-gland into the surrounding water, producing a smoky cloud. In males one of the arms, called hectocotylized arm, bears a spoon shaped organ at its end. The arm is used to caress the female and deposit spermatophores beneath its mantle. Sexes are separate. Development is direct. There is no larval stage. It feed upon crabs, bivalves and fishes etc.

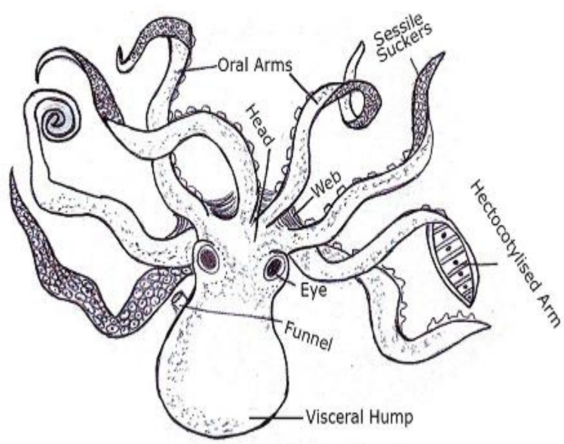


Fig 9.1 Octopus

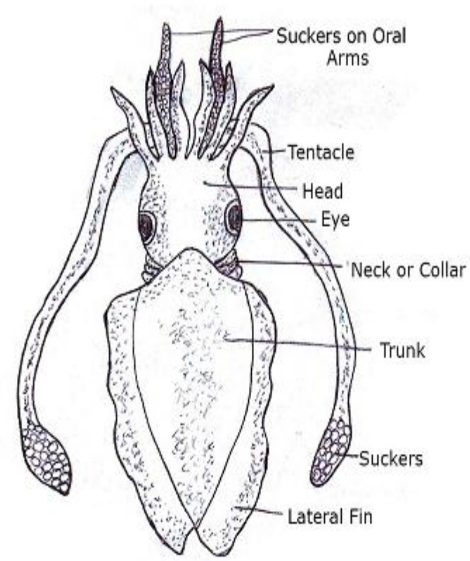
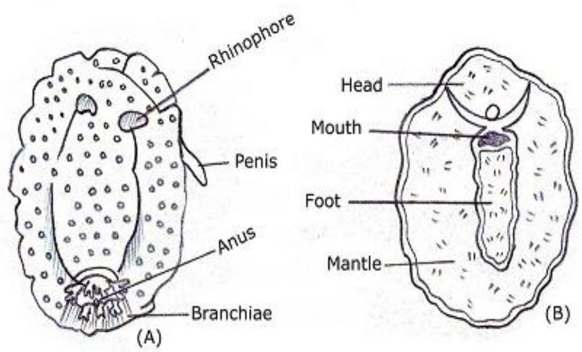


Fig.9.2 Sepia

2. *Sepia*: *Sepia* (Commony known as cuttle fish) is an invertebrate belonging to the Phylum Mollusca (fig 2). It is a marine animal that occupies shallow to mid water and is often associated with coral reefs. Body is unsegmented, bilaterally symmetrical and soft and is divisible into a large head, a small neck or collar and trunk. The head is well developed, bears a pair of eyes and 10 oral arms which are a modification of foot. Eight oral arms are smaller while two are longer and are called tentacles. The trunk extends into flaps called lateral fins on either side that help the animal in swimming. It is covered by a thick muscular mantle, enclosing a large mantle cavity, on the ventral side which contains viscera. The Sexes are separate and reproduction is sexual. It is nocturnal and carnivorous.

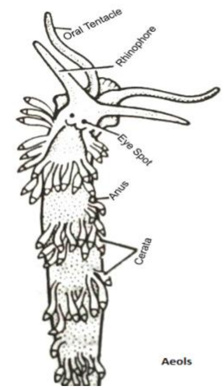
Sepia contains a large ink gland which opens in the rectum. It secretes a dark brown or black fluid stored in a reservoir. When attacked, *Sepia* confuses the predator by releasing ink through the anus and runs away. The homeopathic remedy S*epia* is prepared from the dark brownish-grey colored pigment obtained from the ink sac of the common cuttlefish and is used to cure a number of health problems, especially those related to women's reproductive organs.

3. Doris: *Doris* (Commonly known as sea-lemon) is a sluggish marine animal found under stones at low tide marks. Head bears a pair of short retractile olfactory tentacles called rhinophores. Mantle is usually pigmented and contains calcareous spicules and tubercles. Mouth is present on ventral side. Foot is ventral with a broad sole for creeping. The body is bilaterally symmetrical, unsegmented, flat, short and oval with convex dorsal surface. The animal is bisexual; the penis and the genital aperture lie asymmetrically on the right side. The anus lies mid-dorsally near the posterior end and is surrounded by a circlet of feathery, retractile secondary gills, called cerata. Development includes a free-swimming veliger larva.



A - Dorsal View, B - Ventral View

Fig. 3 *Doris*



4. *Chiton*: *Chitons* (formerly known as Amphineura) are marine molluscs which belong to class Amphineura and subclass Polyplacophora (fig. 4). Their size varies from small to large. About 940 extinct and 430 fossil species are recognized. *Chiton* is commonly known as sea-mice. *Chitons* are mainly found in shallow water, often under rocks and other shells, but several genera can be found in water as deep as 5,000 ft. Some are actively carnivorous, feeding on small crustaceans by smothering them with the girdle; e.g., Lepidochitona. They become active at twilight and move around very slowly in search of food. Most are grazers, and with a multi-toothed radula, they can feed on small algae and other tiny organisms.

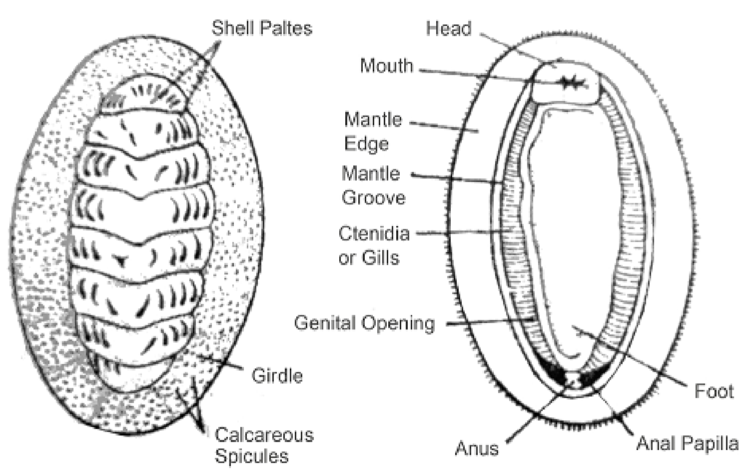


Fig.9.4 Chiton (A) Dorsal View (B) Ventral View

Body is unsegmented, bilaterally symmetrical and dorso-ventrally compressed. It consists of shell, foot, mantle and visceral mass. Shell is calcareous and is present on the dorsal side and is composed of 8 overlapping plates. Head is not distinct. Eyes and tentacles are absent. Foot is ventral, broad, sole-like and muscular, adapted for creeping and adhering. Mantle covers greater part of body and partly covers the edges of the shell plates. Mouth and anus are at opposite ends. Gills lie along whole length of mantle groove. Sexes are separate, gonad is single and median. Fertilization is external. Development is indirect through trochophore larva.

5. *Pecten*: *Pecten* (Commonly known as scallop) is a free-swimming marine molluscs that lives on sea bottom of 10 fathoms deep. Shell is beautifully ribbed by radiating lines. The two shell valves are unequal, the right being larger and more convex and the animal rests on this valve. Locomotion takes place in spurts; the swimming is affected by the rapid opening and closing of shell valves. Foot is very much reduced. Two large gills are present. Pectens are bisexual. It is found mainly in U.S.A. and India.

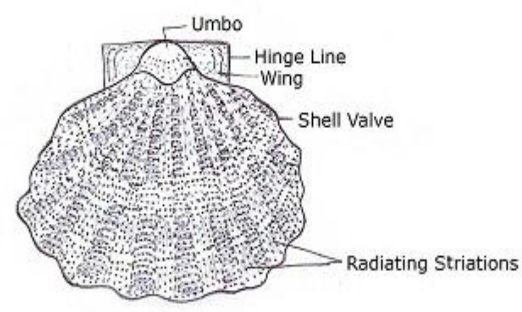


Fig 5. ***Pecten***

6. *Loligo*: *Loligo* is commonly called sea squid and is found all over the world in shallow to mid waters. Body is spindle or torpedo-shaped and divisible into head, foot and visceral hump. The head is well developed, bears a pair of eyes and ten oral arms which are a modification of foot. Eight oral arms are smaller while two are longer and are called tentacles. Shell is internal and cartilaginous. Two nephridia or kidneys are also present. Sexes are separate. An ink sac is present and serves for defence. *Loligo* is used as food by Chinese and Italians and also as bait for marine fishing.

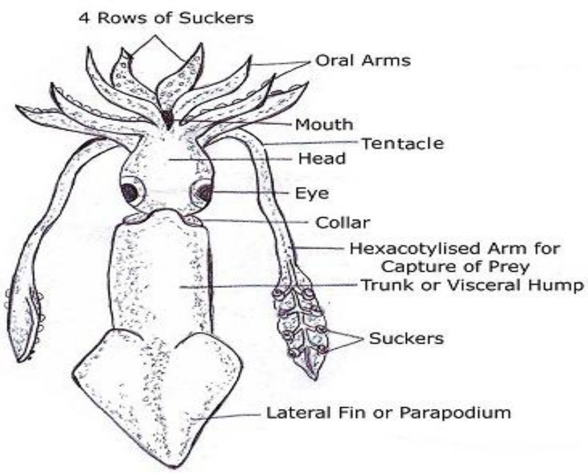


Fig. 6: *Loligo*

7. *Dentalium*: *Dentalium* (Commonly known as tusk shell) is a marine mollusc found world over in the sublittoral zone of seas. It measures 2-5 cm in length. It lies in a tubular, bilaterally symmetrical shell open at both ends. Head and foot project out from the anterior aperture of the shell. Head bears a mouth surrounded by filiform tentacles called captacula. Eyes and osphradium are absent. Mantle is entirely within the shell. The foot is long pointed, spade-like and highly extensible adapted for digging and burrowing **(Rastogi)**. Sexes are separate. Development is indirect and includes a trochophore larva. Shell of *Dentilium* is used for ornamental purposes. Its shells were once used by Red Indians of America as currency. It feeds on micorganisms like diatoms and foraminifera.

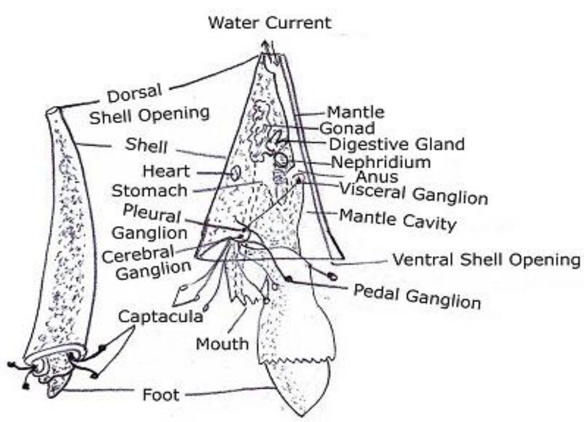


Fig. 7: *Dentalium*

7. ***Unio***: *Unio* is commonly known as freshwater mussel (fig. 8). Freshwater mussels are found in freshwater lakes, rivers and streams, inhabiting the surface layers of the muddy beds of rivers and lakes. It crawls slowly with the help of its plough-like, wedge-shaped muscular foot that leaves a deep trail all along its journey. It usually moves to shallow

places by night and retires to deeper places by day. Food consists of microscopic organisms, both animals and plants, which are fed upon by filter-feeding mechanism involving both ciliary as well as mucoid movements. Animal responds to light, touch or some other stimulus by withdrawing its foot and closing the siphons, meant for incoming and outgoing water currents. Soft-bodied animal is completely enclosed within a calcareous shell which represents its exoskeleton. *Unio* is dioecious, i.e. the sexes are separate, but there is no external dimorphism.

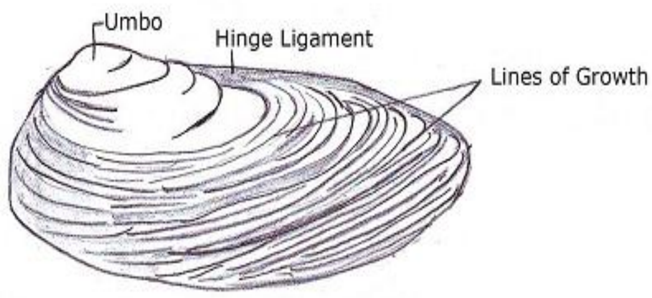


Fig. 8: ***Unio***

8. ***Aplysia***: *Aplysia* is commonly known as sea-hare. It is a marine animal found in tropical waters. It is found in India, West Indies and on the Florida Coast. It crawls over the surface of rocks and boulders. The body is soft and lumpy with a thin flexible plate-like shell covered by mantle. The head has two pairs of tentacles. The posterior pair tentacles become ear-like and are called rhinophores. The foot is broad and flat and bears a pair of lateral folds parapodia that help in swimming. Mantle possesses unicellular ink glands. These secrete purple ink used for defence. It is bisexual. It has a single gonoduct. *Aplysia* is known to form mating chains with up to 20 animals. The eggs are yellow-green, and change after 8 to 9 days into a brown color before larvae hatch. The life span is assumed to be around a year. Cooler temperature delays spawning and has been shown to extend the lifespan. Sea hare is hermaphroditic, acting as male and female simultaneously during mating. *Aplysia* is herbivorous. Its diet consists primarily of red algae like *Plocamium pacificum*, *Ceramium eatonianum* and *Laurencia pacifica* which gives the animal its typically reddish or pinkish coloration. Thus *Aplysia* resembles the food it grazes on and cannot be distinguished easily from the seaweed unless the animal is moving.

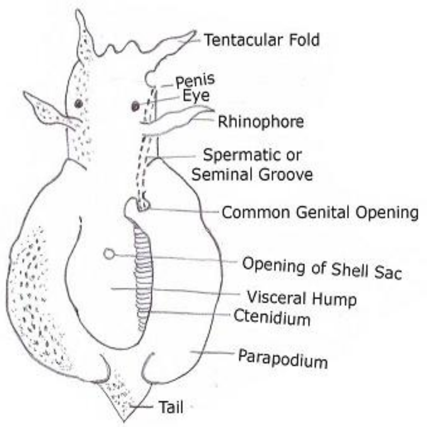


Fig. 9: ***Aplysia***

9. ***Eolis***: *Eolis* (Commonly known as sea slug) is a marine slug-like gastropod found in shallow waters crawling under surface of seaweeds. It is a small neudibranch 1 or 2 cm in length. Head bears two pair of cylindrical retractile tentacles and sessile eyes at the base of the posterior pair of tentacles.The mouth is prominent and can be most easily seen from the ventral view. Foot is muscular and ventral and serves for locomotion. Shell, mantle and true gills are absent. It is hermaphroditic and common gonad is protrandric. The animal is said to feed on hydroids which are digested and their undischarged nematocysts are collected in the cerata and discharged on irritation.

9.4- Study of Pila (Apple Snai

***Pila* globosa:**

Systematic position

Phylum Mollusca

Class Gastropoda

Order Mesogastropoda

Family Pilidae

Genus *Pila*

Species *globosa*

9.4.1 Habit and habitat: -

Pila globosa is one of the largest freshwater molluscs. *Pila* is amphibious. It is commonly found in ponds, lakes, tanks, pools, marshes, paddy fields, streams and rivers of Northern India. It is found in large numbers in those areas which are rich in aquatic plants like *Vallisneria* and *Pistia*. It is a voracious eater and feeds upon plant scrapings with the help of its chitinous jaws and radular teeth. It overcomes long periods of drought in a dormant condition by burying in the mud with its shell aperture tightly closed. This period of inactivity is called summer sleep or aestivation.

It creeps very slowly with the help of its ventral muscular foot, covering about 5 cm per minute. During rainy season, it leaves the ponds and makes long terrestrial excursions on land breathing directly in the air. It is commonly used as food by some people, mainly the tribals and lower economic groups in Nepal, the Sunderbans, as well as the people of West Bengal, Bihar, Uttar Pradesh and other parts of India. It is one of the most preferred gastropod species utilised by tribal people as food. This species lives in permanent and temporary stagnant water bodies and uses dry areas for breeding. Adults survive the dry season buried in soil.

9.4.2:-External morphology:

1. Shell: The shell of *Pila*, as in other Gastropoda, is univalve but coiled around a central axis in a right-handed spiral. The shell consists of 6 ½ such whorls which gradually increase in size from behind to front. The surface of the whorls is marked by faint vertical ridges, the lines of growth. A few of the latter are more prominent and are called as varices.The small rounded tip of the shell represents the apex and the whorl surrounding it is the apical whorl. The lowermost whorl is largest and is known as body whorl. The line of contact between two adjacent whorls is called as suture.

The body and penultimate whorls (except the body whorl) are called as spire. The body whorl of the shell opens to the exterior by a wide opening, the shell mouth. Its smooth continuous margin is known as peristome. It is bounded by an outer lip and an inner columnar lip. When the animal body is completely withdrawn, the shell mouth is closed by a flat, oblong plate, the operculum. The columnella of the shell is hollow and opens to the exterior through umbilicus. As such the shell is known as umbilicate (Rastogi).

Microscopic structure of shell: Like all other molluscs, *Pila's shell* is secreted by the underlying mantle. It consists of Periostracum, Ostracum and Hypostracum. The Periostracum is the thin outermost layer made of conchiolin. Ostracum is the middle layer made of calcium carbonate deposited as plates running in the direction of shell coiling. Hypostracum or nacreous layer or mother of pearl is the innermost layer. Its plates are also made of calcium carbonates that run parallel to the margin of aperture.

Operculum: Operculum is a calcarrous plate formed by cuticular secretion of the glandular cells of the animal foot. The inner surface of the opercular exhibits an elliptical area of creamy colour, the boss, which is surrounded by a shallow groove. It acts as a lid that the snail uses to close the mouth when it withdraws into the shell.

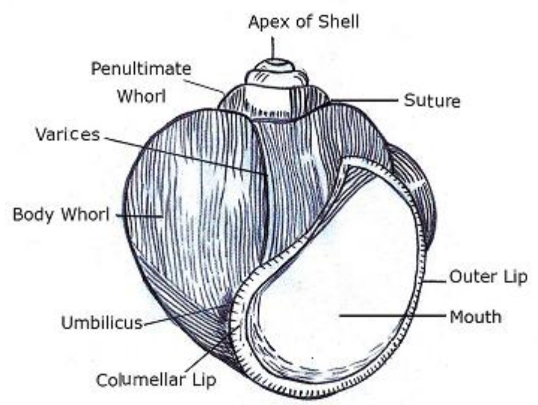


Fig 10. Pila:**The shell with operculum**

2. Body: Body of *Pila* is divisible into four regions - head, foot, visceral mass and mantle.

1. Head:

Head is the anterior fleshy part of the body overhanging the foot. It bears mouth, two pairs of contractile tentacles and a pair of eyes. The tentacles arise from behind the snout from the dorsal surface of the head. The anterior pair of tentacles is called the cephalic tentacles or labial palps and is prolongations of the sides of the head. Mouth is a vertical slit-like aperture lying ventrally between the bases of the cephalic tentacles. The posterior pair of tentacles is long, fleshy and contractile and is the true tentacles.

2. Foot:

Foot is the locomotory organ of *Pila* and lies below the head. It is highly contractile and muscular with the muscle fibres arranged crosswise and lengthwise. It contains pedal glands, the secretions of which form a slime trail during locomotion. The anterior part of the foot is round and the posterior dorsal surface bears the operculum. When the foot is withdrawn, operculum completely fits into the mouth of shell and closes it. The head and foot together constitute the head-foot complex. The two are connected to the visceral mass through a slight constriction.

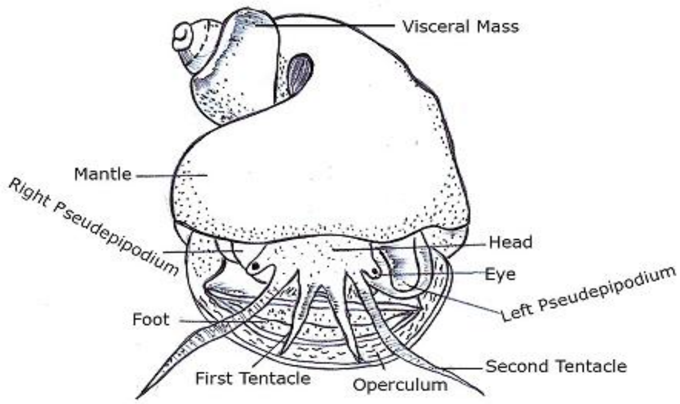
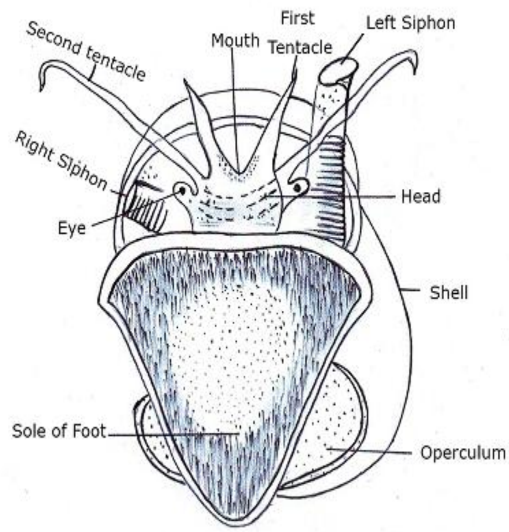


Fig11. ***Pila*****: Body after removing the shell**

3. Visceral mass: All visceral organs are contained in this lump like structure that lies above the head-foot complex. It is soft and grey to the dark brown in colour. It is spiral and coiled-like the shell in which it lies, occupying the body whorl as well as the spire. Visceral mass shows the phenomenon of torsion.

4. Mantle: Skin of the visceral mass forms a thin and delicate covering called the mantle. It is a fleshy layer or cape that secretes the shell of the mollusc. It protects the soft visceral mass and also acts as a protection cloak or hood over the head and its appendages when the animal is retracted. Anteriorly, the mantle becomes thickened and pigmented. A long, narrow supra-marginal groove runs along the thickened free edge of the mantle. It encloses a spacious cavity (mantle cavity or pallial cavity) that contains some of the important organs of the animal and together constitutes the pallial complex.



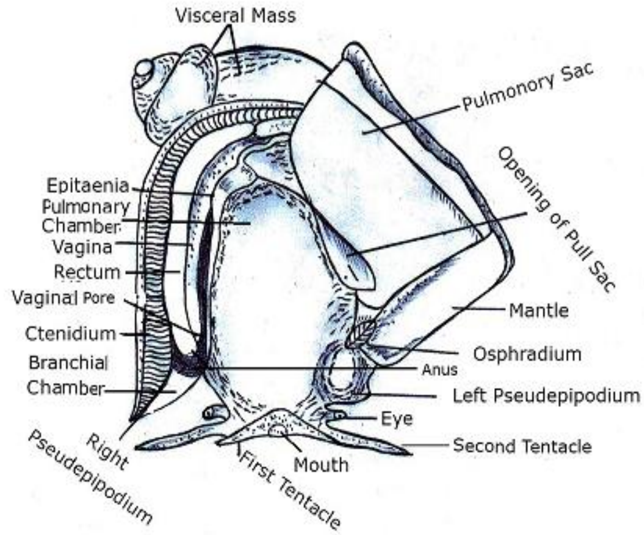


Fig.13 Pila:Mental Cavity and pallial complex

Fig.12 Ventral view to show muscular foot

Mantle cavity is the space between the mantle and the visceral mass. A longitudinal ridge known as epitaenium imperfectly divides mantle cavity into smaller right branchial chamber and larger left pulmonary chamber. The rectum is present on the left of the ctenidium on the floor of the branchial chamber and opens to the outside by the anus which is situated just near the base of the right nuchal lobe. Anterior renal chamber projects as a reddish sac in the branchial chamber near the posterior end of the epitaenia and opens into the mantle cavity by an oblique slit. The genital duct is present on the left of the rectum and the genital aperture is present very close to the anus (Kotpal).

Nervous system:

The nervous system is well developed and comprises of two main parts – Central Nervous System and Peripheral Nervous System. Central Nervous System consists of ganglia and their commissures (connections between similar ganglia) and connectives (connections between dissimilar ganglia). The main ganglia include cerebral, buccal, pleuro-pedal, supra-intestinal and visceral. Of these supra and infra-intestinal ganglia are unpaired and rest are paired ganglions. The peripheral nervous system consists of nerves arising from CNS and innervates various parts of the body.

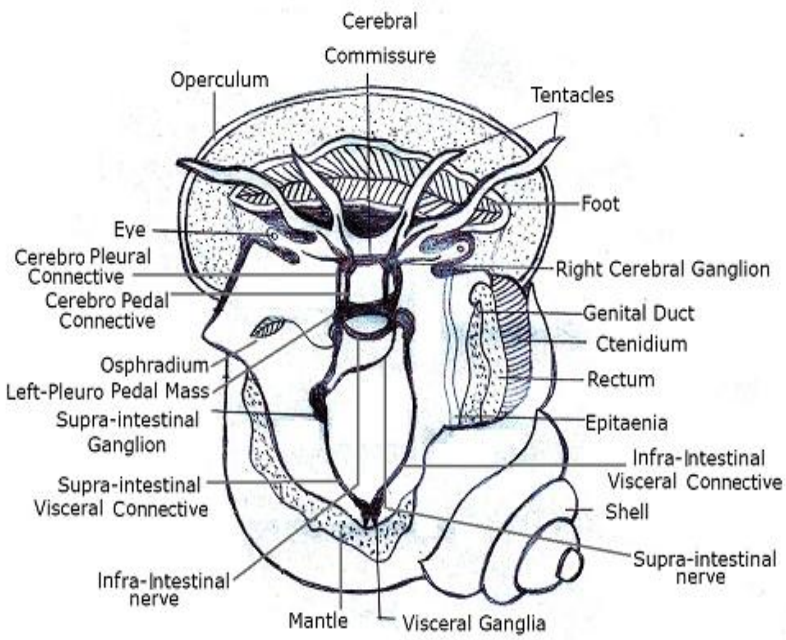


Fig. 14 : Nervous sytem of Pila

1. Ganglia: Paired ganglia, which are aggregations of nerve cells, are as follows.

(a) Cerebral ganglia: A pair of roughly triangular ganglia, situated anteriorly on the dorso-lateral sides of the buccal mass.

(b) Buccal ganglia: A pair of small, triangular ganglia, lying dorso-laterally one on either side at the junction of the buccal mass and oesophagus, partly embedded in the muscles. It sends off several nerves to the buccal mass, salivary glands, oesophageal pouch and a greater part of oesophagus.

(c) Pleuro-pedal ganglia: A pair of large, somewhat triangular, ganglionic mass present one or either ventro-lateral side of the buccal mass. Each one is formed by the fusion of an outer pleural and an inner pedal ganglion, separated by a faint notch. Right pleura-pedal ganglionic mass also consists of the infra-intestinal ganglion fused with it. It supplies nerves to the foot, parietal nuchal lobe, copulatory organ, columellar muscles, mantle, ospharidium and epitaenia.

(d) Supra-intestinal ganglion: An unpaired fusiform ganglion, lying in a sinus behind the left pleura-pedal ganglionic mass. It supplies nerves to mantle and ctenidium.

(e) Visceral ganglia: A single ganglionic mass representing two fused ganglia, situated at the lower end of the visceral mass. It provides (i) a right nerve to renal organs, reproductive organs and to the intestine (ii) a left nerve to the pericardium, stomach, liver and reproductive organs. (iii) a few snall nerves to the neighbouring nerves.

2. Commissures: Commissures are those nerves which establish connections between two similar ganglia. In *Pila* these constitute-

(a) Cerebral commissure: A thick band of nerve connecting two cerebral ganglia and lying dorsally to the buccal mass.

(b) Buccal commissure: A fine nerve which connect the two buccal ganglia and runs transversely on the ventral side of the oesophagus.

(c) Pedal commissures: Two thick nervous bands that lay one above the other underneath the buccal mass and connect the two pedal ganglia together.

3. Connectives: Connectives are those nerves which connect two different ganglia. In the nervous system of *Pila*, these are-

(a) Two cerebro-buccal connectives: These connect, on either side, the cerebral ganglion and buccal ganglion together.

(b) Two cerebro-pleural connectives: These connect, on either side, the cerebral and outer pleural ganglion of the pleuro-pedal ganglionic mass.

(c) Two cerebro-pedal connectives: These connect, on either side, the cerebral and inner pedal ganglion of the pleura-pedal ganglionic mass.

(d) Pleuro-infra intestinal connective: Also called infra-intestinal nerve, it is a nerve connection between the pleural ganglion of the left pleura-pedal mass and the infra-intestinal ganglion which is fused with the right pleura-pedal mass.

(e) Infra-intestinal visceral connective: Running below the intestine, it is a long nerve that connects the visceral ganglion with the infra-intestinal part of the right pleuro-pedal-infra-intestinal ganglionic mass.

(f) Supra-intestinal visceral connective: Running above the intestine, it is a slender nerve that connects the visceral ganglion with the supra-intestinal ganglion.

(g) Supra-intestinal-pleural connective: Also called the supra-intestinal nerve, it connects the supra-intestinal ganglion with the pleural part of the right pleuro-pedal-infra-intestinal ganglionic mass.

(h) Zygoneury: It is a nerve connection between the pleural part of the left pleuropedal ganglionic mass and supra-intestinal ganglion.

9.4.2- REPRODUCTION:-

In *Pila* the sexes are separate and sexual dimorphism is distinct. Female shell is larger and more globular than that of the male. The copulatory organs or penis is well developed in male but poorly developed in female.

Male Reroductive system:

The male reproductive system comprises of:

1. Testis
2. Vasa efferentia
3. Vas deferens
4. Copulatory organs
5. Hypobranchial gland

1. Testis: Testis is a single, flat, plate-like and triangular whitish structure, occupying the upper part of the first two or three whorls of the shell. It is separated from the shell by a thin cutaneous membrane.

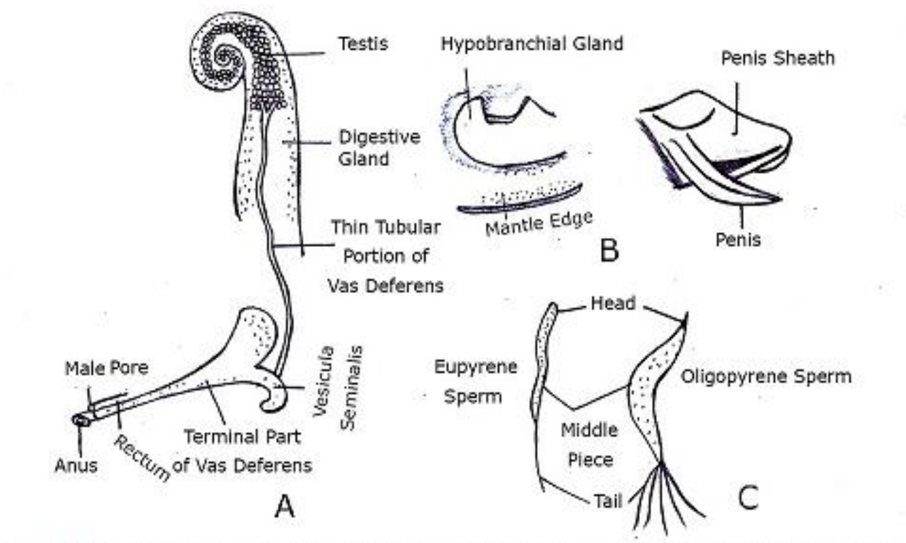


Fig. 15 *Pila:* (A) Male reproductive organs (B) Male copulatory organs (C) Sperms

Two types of sperms are produced in the testis are-

(1) Eupyrene sperm: These are small, thread-like, motile and capable of fertilizing ova. It measures about 25 µ long and 1.2 µ broad with a head and tail. It has twisted nucleus and a single axial filament and functional.

(2) Oligopyrene sperm: These are large, spindle-like, non-motile and incapable of fertilizing ova. It measures about 32.5 µ long and 3 µ broad with distinct head and a tail of 4 or 5 cilia. It has broad curved nucleus and with many axial filaments and are sluggish and non functional.

2. Vasa efferentia: These are fine ducts that arise from the different regions of the testis to unite to form a large common duct, the vas deferens.

3. Vas deferens: The vas deferens commences from the posterior part of the testis and differentiated into three parts:

(a) Proximal tubular part: The proximal tubular part is thin walled narrow structure and forms posterior part of testis under the skin. It runs along inner side of the digestive gland upto the posterior renal chamber and finally turns towards the left to approach the pericardium. After reaching the pericardium it opens into the ventral side of vesicula seminalis.

(b) Vesicula seminalis: Vesicula seminalis is curved, swollen and flask shaped structure with a blind rounded posterior prolongation.

(c) Terminal glandular part: It is distal thick-walled glandular part of the vas deferens which runs along the left side of the rectum into the branchial chamber and opens into it by male genital pore.

4. Copulatory organs: Copulatory organ or Penis arises separately from the mantle edge in front of the anus. It is a long, slightly curved and flagellar structure with a swollen base and a tapering free end. Penis remains enclosed in a penis sheath formed by a thick, glandular, yellow colored, flap attached to the mantle along its side, while its free left edge is rolled up to form a spout-like covering for the penis. Penis is highly extensile; being about 1.5 cm long but can attains a length of 4 cm during copulation.

5. Hypobranchial gland: The hypobranchial gland is situated at the base of penis sheath and is oval and thick with pleated surface. It consists of tall cells containing small basal nuclei. Due to absence of duct its secretions are released directly upon its surface.

Female Reproductive system:

The female reproductive system comprises of:

1. Ovary
2. Oviduct
3. Receptaculum seminis
4. Uterus
5. Vagina
6. Copulatory organ
7. Hypobranchial gland.

1. Ovary: Ovary is a branched structure of orange colour attached to the inner side of the digestive gland. Branches of the ovary or acini are single layered and flask shaped structure. The ovary occupies the first, second and sometimes also the third whorl of the shell. Their outer rounded end is closed and the inner slender tubular end unites to form a single oviduct.

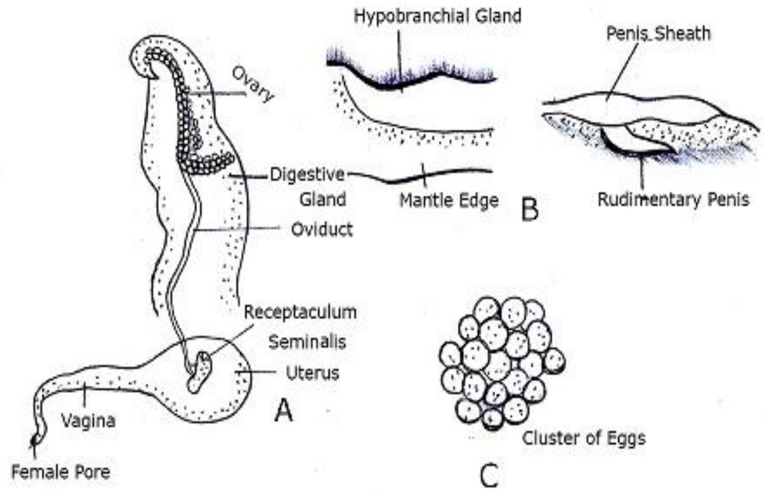


Fig. 16*Pila*: Female reproductive organs (B) Rudimentary penis (C) Eggs

2. Oviduct: The oviduct is a narrow and transparent tube arising from the ovary and passing downwards along the margin of the digestive gland. It turns downwards near the renal organ and then upwards to open into the receptaculum seminis.

3. Receptaculum seminis: Receptaculum seminis is a small bean-shaped structure and is situated at the junction of oviduct and uterus. It is enclosed in the cavity of posterior renal chamber. It is meant for storing sperms recieved from the male during copulation.

4. Uterus: The uterus is a large, yellow, pear-shaped structure. It lies below the the intestine and to the right of the renal chamber. It is differentiated into broad, vesicle-like rounded basal part and a narrow tubular apical part. The former receives the opening of receptaculum seminis and the latter opens into the vagina.

5. Vagina: The terminal narrow part of the oviduct is known as vagina. It is a white cream-coloured tubular part which runs forward on the left side of rectum to open into the branchial chamber.

6. Copulatory organ: The copulatory organ or penis in female represents the rudiment of male penis. It is a thin flagellar structure nearly 6.0mm long and pointed at the tip.

7. Hypobranchial gland: Hypobranchial gland of the female is poorly developed with rudimentary glandular thickening.

Copulation: *Pila* reproduces only during rainy season. Copulation occurs on land or on moist ground of the banks. During copulation the male and female *Pila* come together facing each other with their right nuchal lobes lying opposite to one another. Now the penis and its sheath are inserted into the mantle cavity of the female. The tip of the penis enters the female genital aperture and sperms are transferred through the vagina into the receptaculum seminis of the female.

9.4.3 FERTILISATION AND DEVELOPMENT:-

Fertilization: Fertilization is internal in *Pila*. It takes place in the uterus, where both ova and spermatozoa pass, the former from the ovary and the latter from the receptaculum seminis. Ovulation takes place two days after copulation. Female lays 200-800 eggs at a time in moist earth in a sheltered cavity near ponds and lakes. The development of embryo takes place outside the body.

Development: The eggs are round and pea sized. The eggs consist of an outer whitish shell, enclosing a double shell membrane, with a thick mass of solid white albumen. In the albumen lies a little central mass of liquid albumen containing the embryo. During development, due to torsion, the visceral mass and the shell of embryo become spirally coiled. A young snail emerges from the fertilized egg. The young ones resemble the adult in form.

9.6- Long Answer type questions:-

1. Classify *Pila* upto order?

2. Describe the morphology of the shell of *Pila*?

3. Discuss the nervous system of *Pila*?

4. Describe the reproductive organs of *Pila?*

9.7- Short Answer type questions:-

1.What are some representatives of the phylum Mollusca?
2. In which habitats do molluscs live?

3. What is the morphological feature of molluscs after which the phylum is named?

4. What are examples of the ecological and economic importance of molluscs?

9.8- References

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UNIT 10 : PHYLUM ECHINODERMATA

10.1- OBJECTIVE

1. Understanding the general characters of echinodermata.

2. To understand its classification.

3. To explain some important echinoderms species.

4. Understanding the morphology and habitat of one of the important species of *Asterias*.

5. Understanding the digestion, reproduction and larval development of *Asterias*.

10.2-INTRODCTION

Phylum echinodermata (Gr., echinos=spiny+derma=skin, ata=characterized by) includes exclusively marine invertebrates displaying pentamerous radial symmetry and an endoskeleton of calcareous plates and spines. Jacob Klein gave the name echinodermata. This phylum is a collection of about 7,000 living species and constitute some of the most beautiful members of sea fauna, such as starfishes or sea stars, sea urchins, sea cucumber, sea lillies and sand dollars etc. The name 'starfish' is, however, misleading as theses animals are not true fishes. A more suitable name suggested for them is 'sea star'. Common genera of sea stars are *Asterias*, *Pentaceros*, *Astropecten*, *Solaster*, *Heliaster*, *Luidia*, *Asterina* etc. Genus *Asterias* includes about 150 species of which most common is *A. Rubens*.

The echinoderms are important both biologically and geologically. Biologically, there are few other groupings so abundant in the biotic desert of the deep sea, as well as shallower oceans. Echinoderms generally have remarkable powers of regeneration of tissue, organs, limbs, and of asexual reproduction, and in some cases, complete regeneration from a single limb. Geologically, the value of echinoderms is in their ossified skeletons, which are major contributors to many limestone formations, and can provide valuable clues as to the geological environment.

Echinoderms possess a simple digestive system which varies according to diet. In many species, the large cardiac stomach can be everted and digest food outside the body. Gonads are present in each arm. In echinoderms such as sea stars, every arm bears two rows of tube feet on the oral side which help in attachment to the substratum. Echinoderms are efficient scavengers of decaying matter on the seafloor. They prey upon a variety of small organisms, thereby helping to regulate their numbers. In addition, echinoderms produce vast numbers of larvae that provide food for other planktonic organisms.

10.3.1 General characters

1. Echinoderms are exclusively marine, free living and mostly bottom-dwellers.
2. Organ system grade of body organization.
3. Body triploblastic, coelomate and symmetrical.
4. Body unsegmented with globular, star-like, spherical, discoidal or elongated with radiating arms.
5. Head absent. Body generally pentameric.
6. Body surface with five radial areas, the ambulacra, with tube feet and five inter-radial areas, the inter-ambulacra.
7. Endoskeleton is made up of spines and calcareous spicules.
8. Coelom is a large cavity lined by ciliated peristomium, coelomic fluid with coelomaocytes.
9. Water vascular system or ambulacral system present, usually with a madreporite.
10. Nervous system without brain but with a circum-oral ring and radial nerves.
11. Sense organs are poorly developed.
12. Alimentary canal straight or coiled.
13. Respiratory organs include dermal branchiae, tube feet, respiratory tree and bursae.
14. Circulatory or haemal or blood lacunar system is typically present.
15. Excretory organs absent.
16. Reproduction is usually sexual but few reproduce asexually or by regeneration.
17. Sexes are separate; fertilization is external, development indirect through free-swimming larval forms.

10.3.1 Classification

Subphylum 1. Eleutherozoa (Gr., eleutheros=free+zoios=animal)

Class 1. **Asteroidea** (Gr., eleutheros = star + eidos = form)

1. Starfishes or sea stars.
2. Body includes 5 radiating arms.
3. Tube feet with suckers.
4. Anus and madreporite are present on the aboral surface.
5. Pedicellariae present.

6. Free-living, predaceous, slow creeping and scavengerous.

Subclass 1. **Somasteroidea**

1. Fossil Palaezoic sea stars. *Platasterias latiradiata* is the only living species.

Subclass 2. **Euasteroidea**

1. Living sea stars.

Order 1. **Phanerozonia**

1. Body with marginal plates and papulae on aboral surface.
2. Pedicellariae alveolar or sessile type.
3. Tube feet without suckers.
4. Mostly live in burrows in soft bottom.

Examples: *Astropecten*, *Goniaster*, *Luidia*, *Oreaster*.

Order 2. **Spinulosa**

1. without conspicuous marginal plates but with papulae on both surfaces.
2. Pedicellariae rarely present.
3. Tube feet with suckers.
4. Aboral surface with low spines.

Examples: *Echinaster*, *Solaster*, *Asterina*, *Pteraster*.

Order 3. **Forcipulata**

1. Marginal plates inconspicuous or absent.
2. Pedicellariae pedunculate and straight or crossed.
3. Four rows of tube feet present.

Examples: *Asterias*, *Heliaster*.

Class 2. **Ophiuroidea** (Gr., ophis = snake + oura = tail + eidos = form)

1. Includes brittle stars and allies.
2. Body flattened with a pentamerous and has rounded central disc.
3. Arms usually five, rarely six or seven, and are long, slender, smooth or spiny.
4. Pedicellariae absent.
5. Madreporite on the oral surface.
6. Stomach sac like; anus absent.
7. Ambulacral grooves absent or covered by ossicles; tube feet without suckers.

Order 1. **Ophiurae**

1. Brittle and serpent stars.

2. Small and five-armed.

3. Arms move transversely.

4. Disc and arms covered with plates.

Examples: *Ophioderma*, *Ophiothrix*, *Ophiura*, *Ophiopholis*.

Order 2. **Euryalae**

1. Arms simple and branched, vertical movement.

2. Disc and arm covered by soft skin.

Examples: *Asteronyx*, *Gorgonocephalus* (basket star).

Class 3. **Echinoidea** (Gr., echinos = hedgehog + eidos = form)

1. Sea urchins and dollars.

2. Body spherical, disc-like, oval or heart-shaped.

3. Skeleton with movable spines and three-jawed pedicellariae.

4. Chewing apparatus or Aristotle's lantern with teeth.

5. Ambulacral grooves covered by ossicles.

6. Sexes separate. Gonads pentamerous.

Subclass 1. **Bothriocidaroida**

1. A single row of plates in each inter-ambulacral area.

2. Madreporite radial.

3. without typical lantern.

Examples: Single extinct Ordovician genus Bothriocidaris.

Subclass 2. **Regularia**

1. Body globular, pentamerous, with two rows of inter-ambulacral plates.

2. Aristotle's lantern well developed.

3. Mouth central.

4. Madreporite oral.

5. Anus central on aboral surface with well-developed apical plates.

Order 1. **Lepidocentroida**

1. Test flexible with overlapping plates.

2. Ambulacral plates extend up to mouth lip.

3. Inter-ambulacral plates in more than two rows in extinct forms.

Example: *Palaeodiscus*.

Order 2. Melonechinoida

1. Test spherical and rigid.
2. Ambulacral plates continue to mouth lip.
3. Inter-ambulacral plates in four or more rows.
4. Wholly extinct.

Example: *Melonechinus*.

Order 3. Cidaroida

1. Test globular and rigid.
2. Two rows of long narrow ambulacral plates and two rows of inter-ambulacral plates.
3. No peristomial gills.
4. Anus aboral and central.

Examples: *Histocidaris*, *Goniocidaris*.

Order 4. Diadematoida

1. Test globular usually with compound ambulacral plates.
2. Perisomial gills present.
3. Anus aboral and central.

Examples: *Echinus*, *Diadema*, *Arbacia*.

Subclass 3. Irregularia

1. Body oval or circular flattened oral-aborally.
2. Mouth central or displaced anteriorly on oral surface.
3. Anus marginal, outside the apical system of plates.
4. Tube feet generally not locomotor.

Order 1. Holectypoida

1. Test regular with simple ambulacra and centrally located peristome and apical system.
2. Lantern present.
3. Mostly extinct.

Examples: *Echinoneus*, *Holectypus*.

Order 2. Cassiduloida

1. Aboral ambulacra area petloid, forming a five-armed figure like petals of a flower.
2. Lantern absent.

3. Mostly extinct.

Examples: *Cassidulus*.

Order 3. **Clypeastroida**

1. Test flattened with oval or rounded shape.

2. Mouth central, anus excentric.

3. Aboral ambulacral areas petaloid.

4. Gills absent.

5. Bottom dwellers.

Examples: *Clypeaster*, *Echinocyamus*, *Echinarachinus*.

Order 4. **Spatangoida**

1. Test oval or heart-shaped with excentric mouth and anus.

2. Four aboral ambulacral areas paloid.

3. Gills absent.

4. Lantern absent.

5. Burrowing forms.

Examples: Heart urchins: *Spatangus*, *Hemipneustes*, *Echinocardium lovenia*.

Class 4. **Holothuroidea** (Gr., holothurion = sea cucumber + eidos = form)

1. Sea cucumbers.

2. Body bilaterally symmetrical, elongated on oral-aboral axis having mouth at or near one end and anus at or near the other end body wall leathery.

3. Arms and spines absent.

4. Mouth anterior, surrounded by tentacles.

5. Ambulacral grooves concealed; tube feet with suckers.

6. Respiratory tree for respiration.

Order 1. **Dendrochirota**

1. Tentacles irregularly branched.

2. Podia or tube feet numerous.

3. Respiratory tree present.

Examples: *Cucumaria*, *Thyone*.

Order 2. **Aspidochirota**

1. Tentacles peltate or leaf-like.

2. Podia or tube feet numerous.
3. Pharynx absent.
4. Respiratory tree present.

Examples: *Holothuria*, *Actinopyga*.

Order 3. **Elasipoda**

1. Tentacles leaf-like.
2. Tube feet webbed together to form fins.
3. Respiratory tree absent.
4. Deep-sea dwellers.

Examples: *Pelagothuria*.

Order 4. **Molpadonia**

1. Fifteen digitate tentacles.
2. Tube feet absent.
3. Posterior end tail-like.
4. Respiratory tree present.

Examples: *Caudina*, *Molpadia*.

Order 5. **Apoda**

1. Worm-like sea cucumbers.
2. Respiratory tree or tube feet absent.
3. Burrowing forms.

Examples: *Synapta*, *Leptosynapta*.

Subphylum II. **Pelmatazoa** (Gr., pelmatos = stalk + zooios = animal)

Stalked, sedentary echinoderms.

Class 1. **Crinoidea** (Gr., crinon = lily + eidos = form)

1. Sea lilies.
2. Body attached during part or whole life by an aboral stalk.
3. Mouth and anus on oral surface.
4. Arms with pinnules.
5. Tube feet without suckers; madreporite, spines and pedicellariae absent.

Order. **Articulata**

1. Living sea Lillies and feather stars.

2. Feather stars are sessile and free-swimming.

3. Calyx pentamerous.

Examples: *Antedon* (sea lily), *Neometra* (feather star).

A few other Echinoderms

1. *Echinus*: *Echinus* is commonly called sea-urchin (Fig 1). It is a species of marine invertebrate in the echinidae family. It is a deep sea animal found from intertidal zone to a depth of 5000 meters. In the North Sea, the species is common in all areas with hard substrates. It is found off the coasts of Portugal, Spain, France, Belgium, the Netherlands, Denmark, Norway, Sweden, the United Kingdom and Ireland. Sea urchins feed mainly on algae, but can also feed on sea cucumbers and a wide range of invertebrates, such as mussels, polychaetes, sponges, brittle stars, and crinoids.

It has a globe-shaped body enclosed within a shell or corona and having very long movable spines. The surface of corona is divided into five ambulacral regions alternating with five interambulacral regions. In each ambulacral region, there are two rows of tube feet. Mouth is present on oral surface and is surrounded by peristome. The chewing apparatus or Aristotle's lantern projects from the mouth. Anus is surrounded by a periproct and is present in the centre of the aboral surface. Water-vascular system is well developed. Development is indirect and involves free swimming echinopluteus larva. Removal of the sea urchins results in the overgrowth of seaweeds and the devastation of the coral reef habitat. When present in large numbers, sea urchins can devastate sea-grass beds in the tropics, adversely affecting the organisms dwelling within.

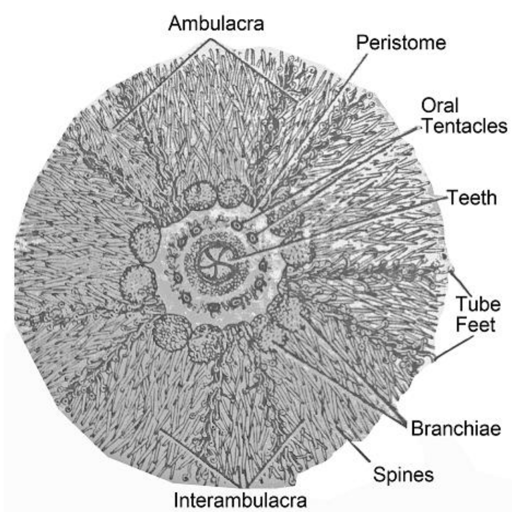

Fig.10.1

2. *Ophioderma*: *Ophioderma* is also known as brittle star. It occurs from the lower shore to depths of around 150m, living on hard substrates. The common brittle star is extremely variable in colouration, ranging from violet, purple or red to yellowish or pale grey, often spotted with red. The arms are usually white or grey with pink bands. Body is made up of a roughly pentagonal central disc and five freely movable arms arising form the base of the disc. Arms are covered with calcareous plates and on either side by spines. Each arm has two grooves called bursal slits. Brittle star moves by means of its tube feet. Development is indirect through free-swimming ophiopluteus larva. The common brittle star is a scavenger, feeding on dead organisms (Fig. 10.2).

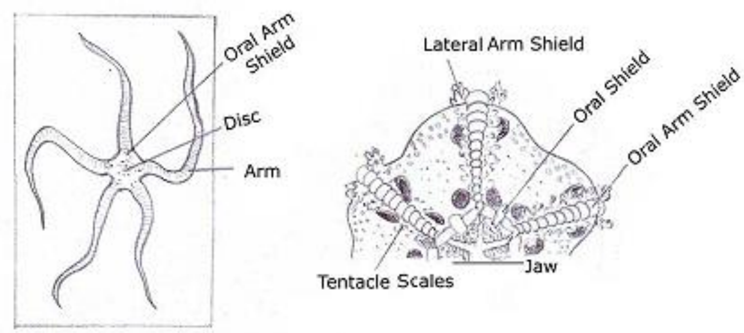

Fig. 2 *Ophioderma*

3. *Holothuria*: *Holothuria* is a genus of marine animals of the family Holothuriidae (Fig. 3). It is commonly known as sea-cucumber and is found in nearly every marine environment, but is most diverse on tropical shallow-water coral reefs. They creep slowly while engulfing micro-organisms alongwith mud. The *Holothuria*, or sea cucumbers, are an abundant and diverse group of worm-like and usually soft-bodied echinoderms. Their habitat ranges from the intertidal, where they may be exposed briefly at low tide, to the floor of the deepest oceanic trenches.

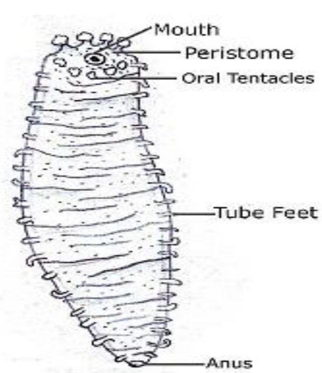

Fig. 3 *Holothuria*

The body is elongated, sausage-shaped, covered with leathery skin and having well developed respiratory tree. The mouth and anus are at the opposite ends. Body bears numerous podia or feet, locomotory on the ventral surface and papilliate on the dorsal surface. Mouth is anteriorly placed, surrounded by 1-30 peltate tentacles. Sexes are separate. Reproduction is sexual. Development is indirect. It includes two larval stages-auricularia and doliolaria respectively. Several species can swim and there are even forms that live their entire lives as plankton, floating with the ocean currents. Sea cucumbers have great economic importance. Some species produce toxins (antimicrobial, anti-inflammatory agents and anticoagulants) that are of interest to pharmaceutical firms. They also form an important part of gourmet food industry in the orient.

4. *Pentaceros*: *Pentaceros* is known as sea pentagon. Central disc is large and the five arms are short and tapering. Aboral surface is convex and bears rows of definitely arranged spines. Oral surface is concave, having a central mouth, communicating with five ambulacral groves, each bearing two double rows of tube feet. Pedicellariae are small and valvate type. *Pentaceros* is very harmful to pearl industry as it feeds on pearly oysters.

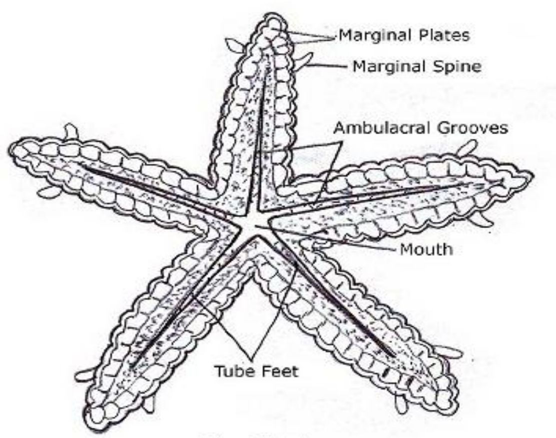

Fig. 4. *Pentaceros*

5. *Astropecten*: *Astropecten* is a common starfish, inhabiting the sandy bottom of seas. Body consists of a large central disc with 5 tapering arms and each having 2 rows of conspicuous marginal plates bearing along spines. Oral surface has a centrally positioned mouth which comes out only occasionally and communicates with 5 ambulacral grooves. Water-vascular system includes two to four polian vesicles in each interradius and the stone canal is structurally complicated. There occurs no brachiolaria larva.

1. ***Antedon***: *Antedon* is commonly known as feather star. It occurs in sea waters of the Atlantic, Western Africa, the Mediterranean and West of Tropical America. It feeds on plankton and debris and has great power of regeneration and autotomy. Body consists of a central disc and a series of ten radiating arms. The upward directed oral surface bears

mouth and a projecting papilla which bears the anus while downward directed aboral surface bears several long appendages called cirri for anchoring or crawling on the substratum. Tube feet or podia without suckers present along the edges of ambulacral grooves. Sexes are separate. Reproduction is sexual. Development includes a free-swimming doliolaria larva.

10.4 *Asterias* (Star fish)

Systematic position:

Phylum	Echinodermata
Subphylum	Eleutherozoa
Class	Asteroidea
Order	Forcipulata
Genus	*Asterias*
Species	*Rubens*

Habits and habitat: *Asterias* are free-living marine animals that can be found at all water depths as well as crawling over rocks and shells. It can be found singly or in masses clinging to piles, piers and other clean solid objects. It exhibits slow crawling movement with the help of arms on the rocky bottom. It avoids direct sun and commonly hides itself under some shelter. Starfish possesses great power of mutility. It any pary of the body is broken due to rough treatment or it is cut to pieces, the lost part or the cut pieces are regenerated.

Asterias are mostly carnivorous and have a mouth, oesophagus, two-part pyloric stomach with a pyloric duct leading to the intestine and rectum, with the anus located in the center of the aboral body surface. These animals possess a true coelom that is modified into a unique circulatory system called a water vascular system. Sea water, instead of blood, is actually used to pump nutrients through their bodies via vascular system. They do not have gills, scales, or fins. It moves by using tiny tube feet located on the underside of its body. Adult sunflower sea stars can move at the astonishing speed of one meter per minute using 15,000 tube feet. Tube feet also help sea stars hold their prey.

Asterias feed mainly upon molluscs, especially bivalves and snails. In addition they act as scavengers on any dead animals. It relishes oysters and hence is very harmful to pearl industry. The crown-of-thorns starfish, which feeds on living polyps of reef corals, has caused extensive short-term damage to coral reefs in some parts of the Pacific and Indian oceans.

10.4.1 Structure

1. Shape and size: Most *Asterias* possess a pentamerous radial symmetry, secondarily derived from a larval bilateral symmetry. The body is flattened and flexible, with a pigmented and ciliated epidermis. Average size of *Asterias* ranges from 10 to 25 cm in diameter.

2. Color: *Asterias* is pink, orange, purple or cream in color. The upper or aboral surface is much darker than the lower or oral surface.

3. External structure: The body is distinguished into a larger central disc and five short, symmetrical rays or arms with broad bases and slightly tapering ends. The arms are not distinctly marked off from the disc. The body is marked into two surfaces: the slightly convex, upper surface which is normally directed upward is the aboral surface and the flat lower surface is oral surface.

Exoskeleton: The body is encased in a tough, hard integument, strengthened with numerous calcareous plates or ossicles.

Aboral surface: The aboral and abactinal surfaces are beset with numerous short but stout spines arranged in irregular rows parallel to the long axis of the arms. All of them are supported on irregular shaped calcareous ossicles embedded in the integument. In the soft interspaces between the dermal ossicles are found small, soft, membranous sac-like outgrowths, papulae or dermal branchiae. Papulae are said to assist in respiration and excretion. The pedicellariae of star-fish are whitish jaw-like structures found on both the aboral and oral surfaces. Each pedicellaria consists of a short, fleshy, stout and movable stalk with two articulating blades, which remain movably articulated with the basilar piece. Anus is situated almost in the centre on the aboral surface. It is in the form of a flat light-coloured nearly circular plate near to the anus and between the bases of the two arms. Its surface is marked with a number of radiating narrow, straight or slightly wavy-groove. Due to the presence of madreporite the body of starfish becomes bilaterally symmetrical. The two arms between which the madreporite is situated are known as bivium, while other three as trivium.

Oral surface: The mouth is situated in the centre of the oral surface in the form of a five-rayed aperture.It is enclosed in the pentagonal depressed area, the actinostome and surrounded by thin, membranous peristome and perisomodeal membrane. Ambulacral grooves radiate out from the five corners of the actinostome and extend one to each arm along its middle upto the distal end. Each groove is borderec by two rows of calcareous ambulacral spines. Tube feet are in the form of hollow slender processes present in two rows in each ambulacral groove. These are provided with terminal suckers. These possess great power of distension and help in locomotion. At the end of each ambulacral groove, there is a bright red eye. It is formed of a number of ocelli and perceives light rays. Above each eye is found a small non-retractile sensory tentacle. It is olfactory in nature and perceives sense of smell.

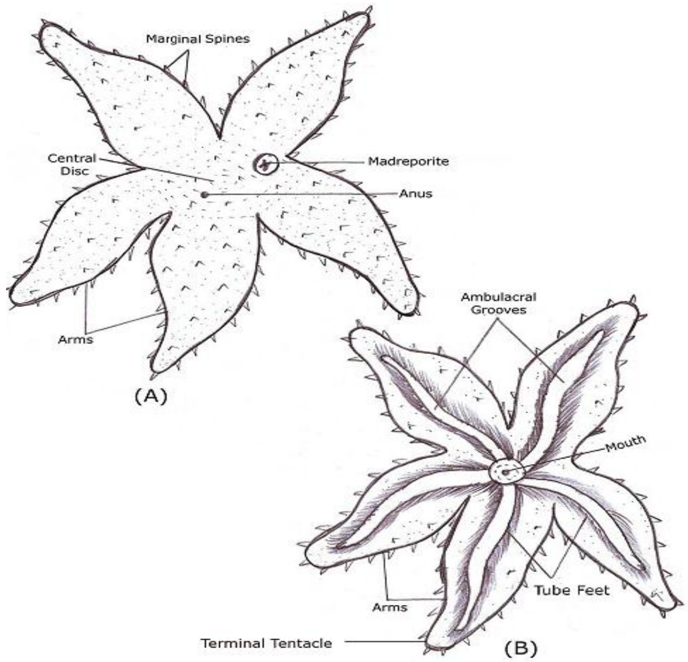

Fig.5 Asterias: External feature (A) Aboral view (B) Oral view

Pedicellariae: Pedicellariae of sea stars are minute, whitish jaw-like structures, found on both the body surfaces, in association with spines (Fig. 6). Pedicellariae may be stalked or sessile. But only stalked type occurs in *Asterias*. Each consists of a short, fleshy and a movable stalk, bearing two articulating calcareous blades or valves, resting upon and articulating with a third calcareous plate, the basal or basilar piece. Such pedicellariae (consisting of three calcareous plates) are termed forcipulate. Opposite surfaces of two valves are serrated. Valves open and close with the help of one pair of

Abductor and two pairs of adductor muscles, respectively. According to disposition of valves, two types of pedicellariae occur in Asterias: (i) Straight type- in these the valves are straight, and when closed, these meet together along their entire length. (ii) Crossed type- in these the two valves cross each other like a pair of scissors.

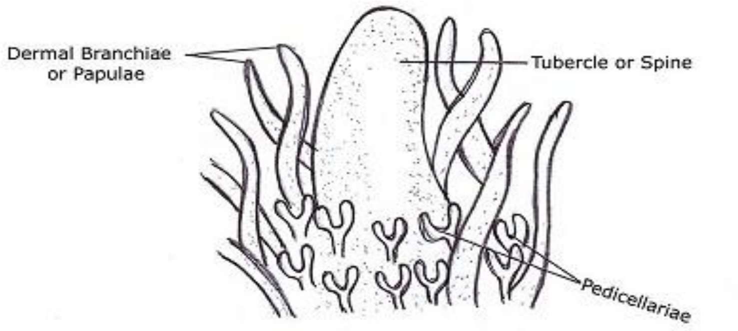

Fig. 6. ***Asterias*** **(A) A cluster of pedicellariae, papulae and tubercle**

The pedicellariae help in the capture and removal of debris and minute organisms, such as larvae, which may settle on the body surface and interfere with respiration by covering the dermal branchiae and tube feet. In some starfishes, the pedicellariae may help in capturing of small prey (Kotpal, 2005).

10.4.2 Locomotion

Locomotion is performed with the help of water-vascular system which sets up a hydraulic pressure. By the action of cilia lining the ambulacral cancals, sea water enters through madreporite and fills up all canals of the system including the tube feet. Body is moved by the steping action of tube feet which are alternately adhered to and released from the substratum. Simultaneously the ampullae of tube feet to these arms contract by the action of their circular muscles. This increases the hydraulic pressure within the tube feet, which consequently elongate, extend forward and adhere firmly to the substratum by vacuum action of their suckers. Adhesion is further strengthened by mucus secreted by the tips of the tube feet. Tube feet then shorten by contracting their longitudinal muscles and forcing some water back into their ampullae. Consequently, the suckers release their hold on the substratum.

During locomotion, one or two arms serve as leading arms, and all the tube feet extend in the same direction in a coordinated manner. However, the tube feet may nt work in unison. As a result, the sea star moves forward steadily but slowly, at a speed of about 15 cm per minute. Sea stars can also climb up the rock by the combined action of their tube feet. If a sea star is accidentally turned upside down, it can correct its posture by folding or arching its arms. In folding action, tips of one or two arms twist to bring their tube feet in contact with the substratum, thus permitting the whole body to fold over and right itself. In arching the upturned body is first raised on its arm tips and then rolled over (Kotpal, 2005).

10.4.3 Mode of Feeding and Digestive system

(I) Alimentay canal: Sea star possesses a complete digestive tract situated in the central disc. Between the mouth and anus it can be differentiated into oesophagus, stomach and intestine (Fig. 8). The alimentary canal is a short but spacious canal distinguished into the following parts:

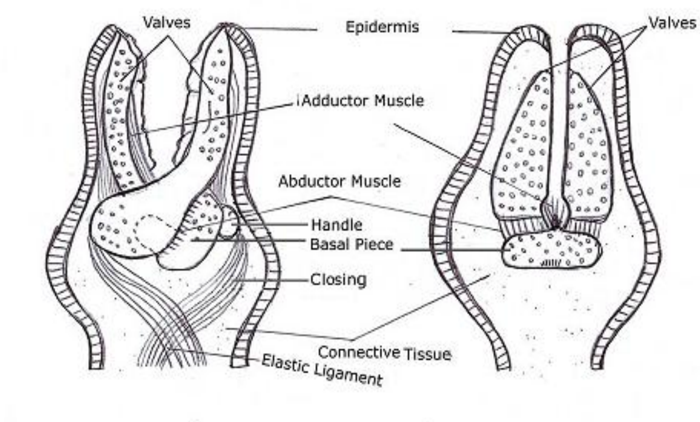

Fig. 7. ***Asterias*** **(B) Crossed type pedicellariae (C) Straight type pedicellariae**

1. Mouth: It is a pentagonal aperture surrounded by a delicate perioral membrane called peristome, situated on the oral side in the centre of central disc. The mouth is surrounded by a sphinter of muscles.

2. **Oesophagus**: Mouth opens into a short and wide oesophagus. It extends vertically to open into the stomach.

3. **Stomach**: It is a spacious sac occupying most of the interior of the central disc. It is differentiated into a larger oral part or cardiac stomach and a smaller aboral part or pyloric stomach.

(a). **Cardiac stomach**: It is a larger oval part connected with the oesophagus. Its wall is thin and greatly folded. The cardiac stomach is held in position by five pairs of mesenteries or the gastric filaments which are formed of connective tissue and muscles. The stomach is capable of everting out through mouth by the action of muscles extending from the body wall.

(b)Pyloric stomach: It is a small, flat pentagonal sac opening aborally into intestine. Angles of the pentagon lie along the radii and each receives a duct, called the pyloric duct, from the corresponding pyloric caeca.

4. **Intestine**: It is a short, narrow, five-sided tube extending vertically to the aboral surface to open out at the anus. It gives out two or three small, branched and brownish appendages, the intestinal or rectal caeca, at interradial positions. Intestinal caeca secreate a brownis fluid, probably excretory in nature. Part of the intestine after caeca is sometimes called the rectum.

5. Anus: The intestine opens on the aboral surface of the central disc by a small rounded aperture, the anus.

(II) Food and feeding mechanism: Star fish is carnivorous, feeding on any slow moving animal but mainly upon molluscs such as oysters, clams, mussels, snails, etc. The fish crabs and barnacles also make its food.

The food is captured with the help of tube feet and arms but the small animals are swallowed. The prey is seized by the tube feet and is folded over by the arms. The cardiac stomach is everted out and is wrapped around the prey.

To feed shelled molluscs i.e. clams, oysters and other bivalves, starfish adopts another fascinating method. It creeps over the clam, holds it with tube feet and brings free margins of the shell close to its mouth. It arches its body assuming a umbrella-like posture. It firmly attaches its tube feet to both the valves of the shell and tries to pull apart the two valves held tightly together by the powerful adductor muscles. It also attaches a few tube feet at the tips of the arms to the substratum to aid in the process. The tube feet gripping the valves of the clam’s shell exert a steady pull till the adductor muscles of the clam are exhausted and give way.

(III) Digestion, absorption and egestion: When cardiac stomach is everted over the captured prey, secretions of stomach and pyloric caeca are poured over it. Enzymes proteases, lipases and amylases, digest the proteins, fats and starches, respectively. Digestion, thus takes place outside the body. Digested materials are then carried into alimentary canal by retraction of cardiac stomach. This is brought about by contraction of gastric ligaments. Digestion of semi-digested materials, if any, is completed in stomach and pyloric caeca. Some small animals are, however, ingested as such and digested only in stomach and pyloric caeca.

Digested food is absorbed mainly by pyloric caeca and distributed to various parts of the body by coelomic fluid. Excess food is stored in the storage cells of the pyloric caeca. As the absorption of food is more or less completed in pyloric caeca, it does not require a long intestine. Hence, the intestine is very short. As animal ingests partially digested food, it has little undigested material, which is mainly eliminated through the mouth itself. Little, if any, egestion takes place through the anus.

10.4.4 Reproduction

Asterias or star-fish is unisexual, but there is no sexual dimorphism. The reproductive organs of primitive type and lack copulatory organs, accessory glands and receptacles or reservoirs for storing sperms and ova.

Gonads: The testes and ovaries are morphologically similar but they show colour variation. The testes are grayish and the ovaries pinkish in colour. There are five pairs of testes or ovaries with one pair at the base of each arm lying freely between pyloric caeca and ampullae of the tube feet.

The gonads develop periodically and their size varies greatly with the proximity of spawning period. At maturity they occupy a considerable portion of the perivisceral space. Each gonad appears as an elongated feathery tuft or bunch of grapes consisting of membranous and rounded follicles. It is enclosed in a genital sinus of the perihaemal system. From the proximal end of each gonad arises a short dilated gonoduct which opens out laterally on the aboral surface by a minute gonopore. The mature sperms and ova are shed in sea water.

Fertilisation: Fertilisation is external. The eggs and sperms are shed in sea-water. The female lays about 200 million eggs in a season. The number of sperms produced is many times more.

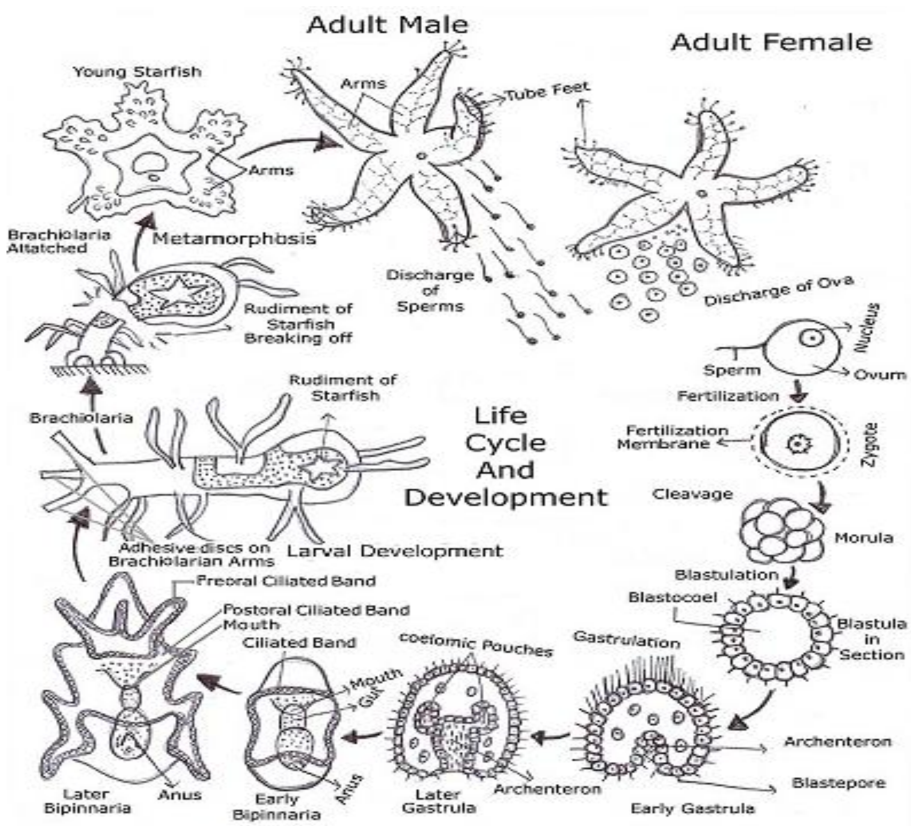

Fig. 8. ***Asteiras*. Life histroy and development**

Embryogeny: Development is indirect and includes various larval stages. The fertilized egg or zygote is spherical, 0.2-0.5 mm in diameter and contains little amount of yolk. The cleavage is rapid and holoblastic so that on the second day, a spherical, hollow, one-layered ciliated blastula or coeloblastula is formed. It swims about in water freely. Its outer layer is formed of ectoderm and inner layer of endoderm. The cavity of gastrula which is lined by endoderm is known as archenteron. It opens to the exterior by a wide aperture called blastopore. On the ventral side, a tubular ingrowth of ectoderm forms the mouth or stomodaeum.

During gastrulation, the advancing tip of archenteron buds off mesenchyme cells into the blastocoels which form the mesenchyme or mesoderm. The advancing or terminal part of archenteron also cuts off on either side a lateral pouch. The laterl pouches take their position on the right and left sides of archenteron and develop into coelomic pouches. These give rise to coelom, its mesodermal lining and water vascular system. The embryo at this stage becomes a free-swimming larva.

Larval development: The development of star-fish includes the following larval stages:

1. Dipleurula larva or early bipinnaria: This is the first larval stage and is commonly found in all the echinoderm. It is egg-shaped and bilaterally symmetrical. The uniform ciliation of the body is replaced by two ciliary wavy bands- a peri-oral band surrounding the mouth, and an aboral band lying inside the mouth. An ectodermal invagination (stomaodaeum) on the ventral side of the embryo becomes continuous with the archenteron. The opening thus developed forms the larval mouth. The archenteron gets differentiated into oesophagus, stomach and intestine. The blastopore becomes the anus. With these changes embryo develops into dipleurula larva capable of independent existence. It actively feeds on diatoms, etc. The aboral band of cilia helps in collecting the food particles. The larva swims near the surface and rotates clock-wise with the help of peri-oral bands of cilia.

2. Bipinnaria larva: The dipleurula larva soon develops on its front side a large pre-oral lobe bordered by a preoral loop of cilia. The pre-oral band now splits into apreoral loop bordering the preoral lobe and postoral loop that borders the lateral lobes. The larva thus formed is called the bipinnaria larva. It swims and feeds freely in water for a few days and enters into the next larval stage, the brachiolaria larva.

3. Brachiolaria larva: The lobes of bipinnaria larva become modified into long, slender, ciliated and contractile larval arms. From the pre-oral lobe arise three short and non-ciliated processes ending into suckers. These processes are called fixing processes. This is now known as brachiolaria larva. It swims and feeds like bipinnaria larva.

Metamorphosis: After a period of 6-7 weeks, the larva settles on some object by its fixing processes. The larval mouth, anus and ciliary bands disappear. New mouth is formed on the left side and new anus on the right of larva. The left and right sides form ultimately the oral and aboral surfaces respectively. Five arm rudiments develop around the oral-aboral axis. Skeletal elements on the arm rudiments and radial canals develop into them. The coelom of the adult develops from the right and left coelomic pouches of the larva. In each arm two pairs of outgrowths from the coelom form the first tube feet and serve for attachment. By further complex internal reorganization a bilaterally symmetrical larva transforms into a radially symmetrical adult star-fish.

10.6.1 Long Answer type questions:-

1. Describe the classification of phylum echinodermata.

2. Give an account of larval forms found in Sea star.

3. Discuss the digestive system of starfish.

4. Explain the reproduction of star fish.

10.6.2 Short Answer type questions:-

1. Write about the external morphology of star fish?

2. Draw a well labeled diagram of starfish?

3. Discuss brachiolaria larva?

4. Comments on bipinnaria larva?

5. Write short notes on *Echinus* and *Holothuria?*

10.6.4 Multiple choice questions:-

1. *Asterias* belong to:
(a) Echinoidea (b) Asteroidea
(c) Ophiurodea (d) Holothuroidea
2. Common name of *Asterias*:
(a) Brittle star (b) Star fish

(c) Sea pentagon (d) Basket star

3. Locomotory organs of starfish:

(a) Polian vesicles (b) Podia

(c) Both (d) None

4. Characteristic feature of echinoderm:

(a) Haemal system (b) Water vascular or ambulacral system

(c) Both (d) None

5. Larval stage in life history of starfish:

(a) Dipleurula (b) Bipinnaria

(c) Brachiolaria (d) All of the above

6. The eggs of Asterias are:

(a) Macrolecithal (b) Microlecithal

(c) Megalecithal (d) Oligolecithal

Answer: 1. B 4. C

2. B 5. D

3. B 6. B

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UNIT 01: PROTOZOA (STUDY OF PERMANENT SLIDES)

1.1-Objectives:

- To study General characters of Phylum Protozoa and its classification up to order.
- Study of permanent slides & study of Protozoan's with particular reference to *Amoeba*, *Paramecium*, *Ceratium*, *Noctiluca* , *Euglena*, *Plasmodium* , *Monocystis* , *Trypnosoma*, *Leishmania* , *Entamoeba* and *Giardia* .

1.3- General Characters of phylum Protozoa:-

1. Protozoa are microscopic animalcules with very simple organization.
2. These are unicellular, having one or more nuclei.
3. The body may be naked or protected either with the pellicle or with skeleton in the form of test or cyst.
4. The single cell of the body performs all the vital activities i.e. there is no physiological division of labour.
5. Animalcules may be "free living, commensal or parasitic. The free living forms are aquatic, inhabiting fresh and slat waters. These may be solitary or colonial. The parasitic forms reside on or inside the body of animals and plants.

6. Nutrition may be holozoic (animal-like), holophytic (plant-like), saprozoic (subsisting on dead organic matter.) saprophytic (feeding on liquid food) or parasitic.
7. The digestion is intracellular and is accomplished inside the food vacuole.
8. Locomotory organs may be pseudopodia or flagella or cilia or absent.
9. Respiration and excretion are brought about through the general body surface. The contractile vacuoles help in osmoregulation and excretion.
10. Asexual reproduction by binary fission, multiple fission and budding and Sexual reproduction by gamete formation or by the conjugation of adult.

Classification of Protozoa:-

<u>Outline Classification of Phylum Protozoa:-</u>

Subphylum: 1. Sarcomastigophora

Superclass: 1. Mastigophora

ClassA. Phytomastigophorea = (Phytoflagellata)

Orders: 1. Chrysomonadida 4. Euglenida
2. Cryptomonadida 5. Chloromonadida
3. Dinoflagellida 6. Volvocida

Class B. Zoomastigophora (Zooflagellata)
1. Rhizomastigida 2. Kinetoplastida
3. Choanoflagellida 4. Diplomonadida
5. Hypermastigida 6. Trichomonadida

Super class: 2 Opalinata

Order: Opalinida

Superclass: 3 Sarcodina

Class: A Rhizopodea

Subclass :(a) Lobosia

Orders: 1. Amoebida 2. Arcellinida (=Testacida)

Subclass b. **Filosia** **Subclass c** : **Granuloreticulosia**

Order: 1. Foraminiferida

Class B. Piroplasmea

Order: Piroplasmida

Class C. Actinopodea

Subclass a. Acantharia b. Heliozoia

c. Radiolaria d. Proteomyxidia

e. Mycetozoa

Subphylum: II Sporozoa

Class A. Telosporea

Subclasses: a. Gregarinia b. coccidian

Classes B Toxoplasmea C. Haplosporea

Subphylum:III Cnidospora

Classes A: Myxosporidea B: Microsporidea

Sub-phylum:IV Ciliophora

Class:a. Ciliata

Subclass:a. Holotricha

1. Gymnostomatida 2. Trichostomatida
3. Chonotrichida 4. Apostomatida
5. Astomatida 6. Hymenostomatida

Subclass:b. Peritrichia

Order: 1. Pertrichida

Subclass:c. Suctoria **Order:** suctorida

Subclass:d. Spirotrichia **Orders**:1. Heterotrichida

2. Oligotrichida **3.** Hypotrichida

1.4-Study of Protozoan's:

1.4.1:- *Amoeba and Paramecium*

Amoeba:-

Systematic position

Phylum:	Protozoa
Subphylum:	Sarcomastigophora
Class:	Rhizopoda
Order:	Amoebida
Genus:	*Amoeba*
Species:	*proteus*

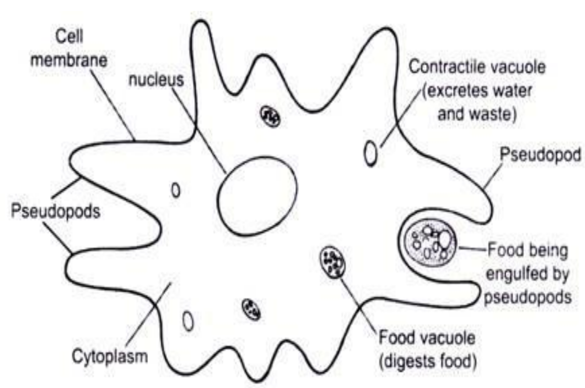


Fig: 1.1 Amoeba

Habit and Habitat:

Amoeba proteus is widely distributed. It is commonly found on the bottom mud or on underside of aquatic vegetation in fresh water ponds, lakes, springs, pools and slow running streams. It is rarely found in, free water as it requires a substratum to glide on from place to place.

Distribution: - It is found all over the world.

Identifying Characters:-

1 Animal is **irregular shape**, with simple or branched pseudopodia measuring 250 to 600 microns in diameter.

2 Cytoplasm is differentiated into **ectoplasm** and **endoplasm.** Ectoplasm contains ectoplasmic ridges.

3 Body of the animal is covered by a thin, delicate and permeable plasma membrane, called as plasma lemma.

4 **Endoplasm** contains nucleus, food vacuole, contractile vacuoles, water globules and crystals.

5 Permanent posterior end is called as uroid.

6 Withdrawal of pseudopodium and new pseudopodium containing endoplasm is present

7 Feeding may be studied by giving carmine. Nutrition is holozoic.

8 Reproduction by binary fission & Multiple fission

9 Amoeba proteus move by the formation of pseudopodia .Pseudopodia are blunt, finger like extensions of the ectoplasm containing endoplasm (lobo podium).

Special significance: *Amoeba* has unique phylogenetic significance and it is referred as immortal. Recently certain free living *Amoeba* has been found to be pathogenic causing meningeo encephalic.

Identification: Since the animal has pseudopodia and above feature, hence it is *Amoeba* ***proteus.***

Paramecium:-

Classification

Phylum …	Protozoa
Subphylum….	Ciliophora
Class …	Ciliata
Subclass…	Euciliata
Order……	Holotricha
Suborder……	Trichostomata
Family…..	Paramecidae
Genus……	*Paramecium*

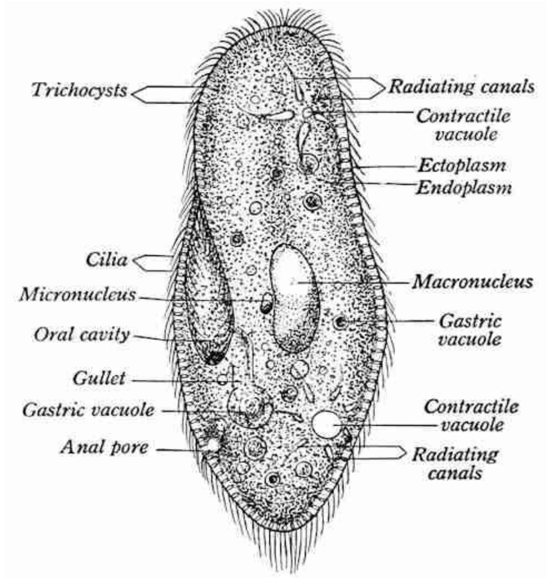


Fig.1.2 Paramecium

Habit and habitat: - *Paramecium* is best known **ciliate**, found in fresh water ponds, rivers, lakes, streams and pools, etc.

Distribution: - It has cosmopolitan distribution.

Identifying Characters:-

1 Commonly called as slipper animalcule, being microscopic, elongated, slipper- shaped cigar-shaped or spindle shaped.

2 Most familiar and extensively studied protozoans.

3 Pellicle covers the body. It is clear firm and elastic cuticular membrane. Pellicle has series of polygonal or hexagonal depressions for trichocysts.

4 *Paramecia* propel themselves by whiplash movements of their cilia, which are arranged in tightly spaced rows around the outside of their body.

5 The beat of each cilium has two phases: a fast "effective stroke," during which the cilium is relatively stiff, followed by a slow "recovery stroke," during which the cilium curls loosely to one side and sweeps forward in a counter-clockwise fashion.

6 The densely arrayed cilia move in a coordinated fashion, with waves of activity moving across the "ciliary carpet," creating an effect sometimes likened to that of the wind blowing across a field of grain.

7 *Paramecia* live mainly by heterotrophy, feeding on bacteria and other small organisms. A few species are mixotrophs, deriving some nutrients from endosymbiontic algae (chlorella) carried in the cytoplasm of the cell.

8 Osmoregulation is carried out by contractile vacuoles, which actively expel water from the cell to compensate for fluid absorbed by osmosis from its surroundings

9 The number of contractile vacuoles varies from one, to many, depending on species

10 *Paramecia* reproduce asexually, by binary fission. During reproduction, the macronucleus splits by a type of amitosis, and the micronuclei undergo mitosis. The cell then divides transversally, and each new cell obtains a copy of the micronucleus and the macronucleus.

11 Fission may occur spontaneously, in the course of the vegetative cell cycle. Under certain conditions, it may be preceded by self-fertilization (auto gamy), or it may follow conjugation, a sexual phenomenon in which *Paramecia* of compatible mating types fuse temporarily and exchange genetic material.

12 During conjugation, the micronuclei of each conjugant divide by meiosis and the haploid gametes pass from one cell to the other. The gametes of each organism then fuse to form diploid micronuclei. The old macronuclei are destroyed, and new ones are developed from the new micronuclei.

13 Auto-gamy or conjugation can be induced by shortage of food at certain points in the *Paramecium*.

Identification: - Since the animal contains slipper- shaped body and two contractile vacuoles while are star –shaped and has all above features hence it is *Paramecium*.

1.4.2 Euglena:-

Classification:-

Phylum … Protozoa

Subphylum … Plasmodroma

Class…. Mastigphora

Order… Euglenoidina

Genus... *Euglena*

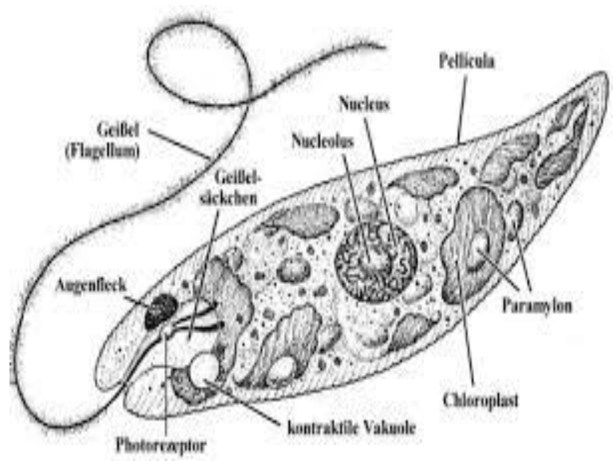


Fig.1.3 Euglena

Habit and Habitat:

- *Euglena* is solitary flagellate found commonly in freshwater ponds, ditches, pods,
And slow running, stream and in brakish water.

Distribution: Cosmopolitin.

Comments:

- Body of animal is simple fuse form, spindle shaped plump like red or green colour.
- *Euglena* measure 50 to 100 microns in length.
- Outer covering is called as pellicle which are marked by an spiral striations called as myonemes
- Anterior end has funneled shaped cytosome which leads into a flask –shaped cytopharynx.
- On one side is a red mass of hematochrome called stigmata which is photosensitive
- Endoplasm contains nucleus ,chloroplast and other ultra structural organelles
- Nutrition holophytic or saprophytic and reproduction by longitudinal division or encystment.
- *Euglena* does not take solid food but lives entirely by autotrophic and saprozoic nutrition. It
- Is unique animal with floral mode of nutrition and funnel mode of life and reproduction?
- *Euglena viridis, E .rubra, E. sanguine* and *E.fusiformis* are common spices they respond to various stimuli such as light heat etc.

Special feature:

- *Euglena* is unique animal with floral mode of nutrition and faunal mode of reproduction.

Identification: Since the animals have chloroplast and all above features, hence it is *Euglena.*

1.4.3:- Ceratium & Noctiluca

Ceratium:-

Classification:

Phylum:Protozoa

Subphylu: Plasmodrom

Class: Mastigophora

Order: Dinoflagelleta

Genus: *Ceratium*

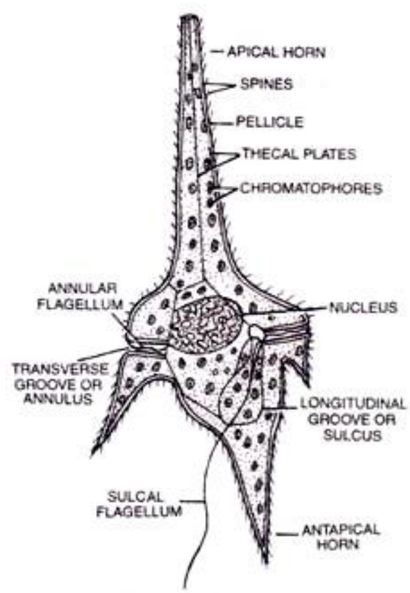


Fig.1.4 *Ceratium*

Comments:

1. Body of *Ceratium*, Fig. 4. Is usually covered with a grooved cellulose wall known as lorica or theca.
2. The covering of the body consists of variable number of plates which are variously sculptured.
3. Shape of the body is triangular due to the presence of an anterior or apical and two lateral spines or horns.
4. There are two grooves on the shell or theca, a transverse and a longitudinal, each containing a flagellum which projects out through a pore.
5. Transverse groove is called annulus and runs like a circular or spiral girdle around the body.
6. Longitudinal groove or sulcus extends obliquely backwards.

7. Single large and central nucleus.
8. Chromatophores are numerous, green in freshwater forms and yellow or brown in marine forms.
9. Nutrition is holophytic or holozoic. Reserve food material starch and oil.
10. Reproduction by fission. Cyst formation also occurs.

Habit and habitat: *Ceratium* is found in freshwater ponds, lakes and in marine plankton.

Distribution: *Ceratium* is common is U.S.A (Woods Hole.)

Noctiluca:-

General Characters:

- Most of them are solitary.
- Most of two flagella of unequal length.
- Cellulose cell wall of plates.
- Ceratium -blooms colour water brown and have fish/septic odor.

Classification:-

Phylum: Protozoa

Subphylum: Plasmodroma

Class: Mastigopora

Subclass: Phytomastigina

Order: Dinoflagellata

Genus: *Noctiluca*

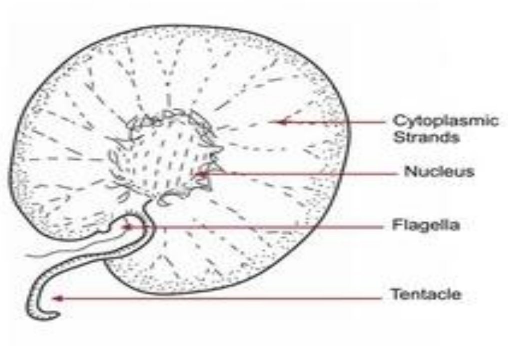


Fig. 1.5 Noctiluca

Habit and habitat: *Nocitiluca* is the most common marine pelagic and bioluminescent floating on the sea usually near the shores often in vast numbers. Sometime their number become so large that they form a thick scum on sea surface cove ring several acres.

Distribution: It is abundantly found in the Atlantic and Pacific oceans.

- **Comments :**
  - Body more or less is the gelatinous spherical with indistinct grooves and measuring Approximately 1 mm in length.
  - Body is covered by a stout pellicle.

- Cytoplasm is highly vacuolated and is differentiated into ectoplasm and endoplasm. Cytoplasm is further differentiated into central cytoplasm and peripheral cytoplasm.
- Mouth is elongated having pouch like cytopharynx.
- Nutrition is holozoic .two flagella procure food particals.
- Reproduction is by gamete formation and fission or by swarm spore formation.

Special features: Whenever the uniform light is seen in the sea, it is undoubtedly due to dinoflagellates, which own the old mystery,"**the burning of sea**"

Idetification: Since the protozoan cantains protoplasmic strands and all above Features, hence it **is Noctiluca**.

1.4.5 Trypanosome Gambians & Plasmodium

Systematic position:

Phylum: Protozoa

Subphylum: Sarcomasigophora

Super class: Mastigophora

Class: Zoomastigophora

Order: Kinetoplastida

Genus: *Trypanosoma*

Species: *gambians*

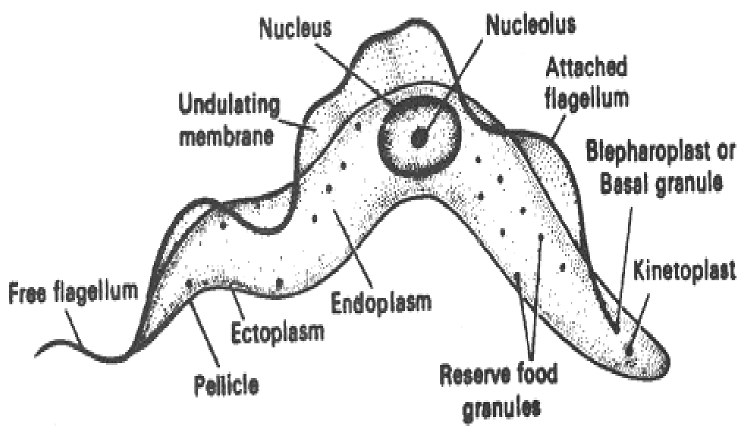


Fig1.6 Trypanosoma

Distribution:-

It is found in Africa and America. It has been reported from India also.

Comments

- Unicellular, microscopic, simple animal commonly found in Africa.
- It is an endoperasite found in blood and other tissues of man and other vertebrates. It causes Trypanosomiasis or Sleeping sickness

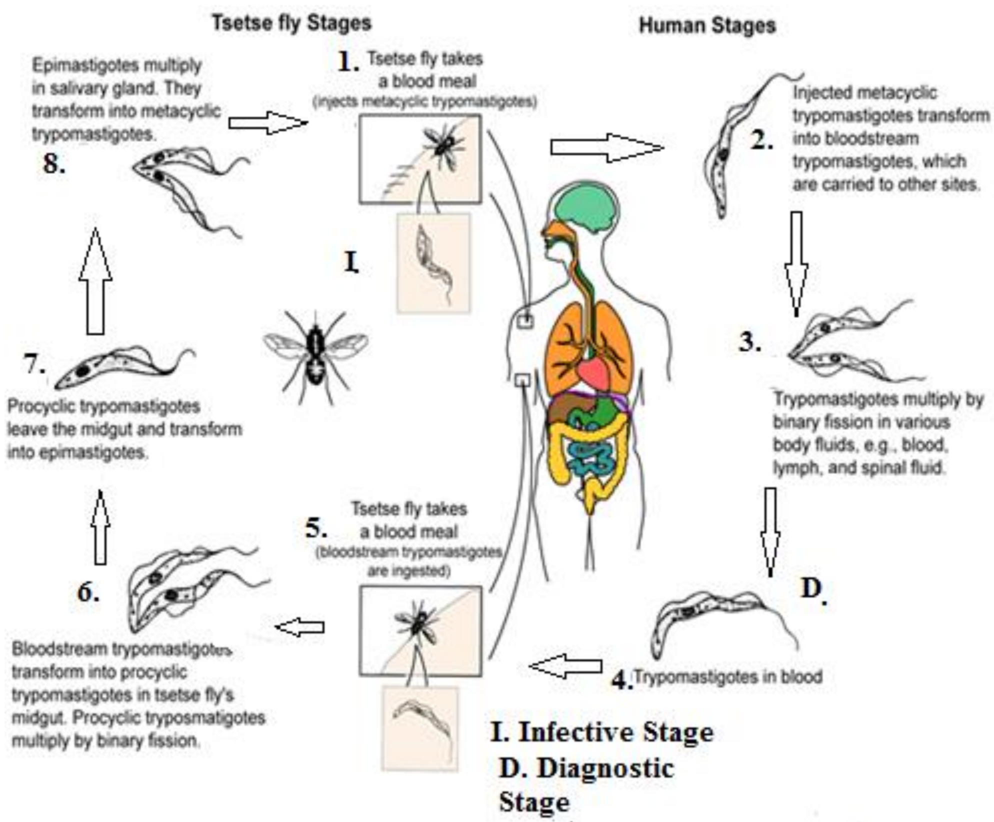


Fig.1.7 Life Cycle of T.gambiense

- It is digenetic i.e. it completes its life cycle in two host:principal host in man and intermediate host is a blood sucking insect Glossina palpalis or Testse fly.
- It is a polymorphic species exists in man and a crithidial forms in testse fly
- A single flagellum arises from a basal body placed near the posterior end
- Reproduction take place by longitudinal binary fission

Host:

It is an endoparasite in blood and tissues of man and other vertebrate's like Pig, Buffaloes and antelopes etc; which are its reservoir hosts.

Symptoms of the Disease:

Several species of trypanosome are known *T.cruzi* cause Chagas disease, *T.brucei* causes Nagana disease but *T. gambiense* and *T.rhodesiense* causing sleeping sickness are by farther most important and well known among the trypanosome species. The parasite invades the cerebrospinal fluid resulting in a recurrent fever. The patient become weak, anemic and loses weight. Strong tendency to fall asleep is observed in the Initial stages and can lead to coma and death if untreated.

Mode of Transmission:

It is transmitted by the bite of the tsetse fly

Therapy:

The perasites are very difficult to control once they haveentered the C.S.F. Druge like Melarcin oxide Orsanine and Pentamedine are effective remedies for the parasite.

Prevention:

1. Eradication of its vector by clearing bushes and spraying insecticides.
2. Killing of reservoir hosts.

Plasmodium:-

Classification:

Phylum: Protozoa
Subphylum: Plasmodroma
Class: sporozoa
Subclss: Telosporidia
Oder: Haemosporidia
Genus: *Plasmodium*

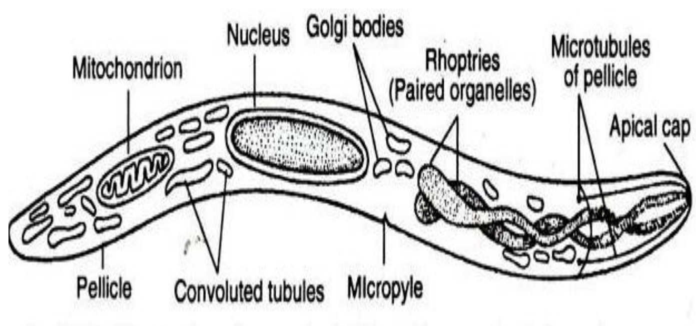


Fig. 1.8 Ultrastructure of sporozoit of Plasmodium

Comments:

- *Plasmodium* is an intracellular blood parasite of man and other vertebrates and causes malaria.
- The life history of plasmodium (Fig.8.40) is completed in two hosts, viz., partl in definitive, host the man and partly in intermediate host, the female anopheles mosquito.
- When an infected female anopheles mosquito bites a man, sporozoites are introduced in the blood from where they reach in live cells through blood streams and multiply to form merozoites.

- After a few schizogenous cycles in the liver, the merozoites enter the red blood corpuscles (R.B.C) and feed on the contents of R.B.C.
- After 2-8 schizogenous changes in the mani blood stream, the merozites assume different shapes and known as gametocytes.
- Gametocytes cannot develop further in the blood of man; therefore they wait for female anopheles mosquito to suck them with the blood.
- When gametocytes are sucked in by the female anopheles with the blood of man, they undergo sporogony for further development.
- There are four species of Plasmodium causing different types of fever:

  1. Plasmodium vivax causes benign tertian fever.
  2. P. Falciparum causes malignant tertian, fever;
  3. P. Malariae causes quratan fever.
  4. P. Ovale causes ovale or mild tertian fever.

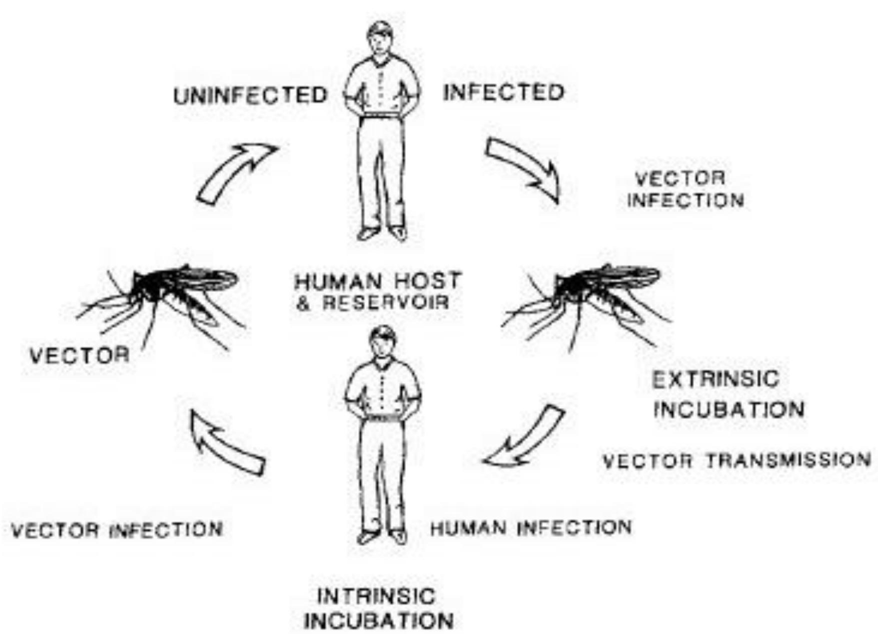


Fig.1.9 Life cycle of Plasmodium

Habit and Habitat:

Plasmodium is found in as an intracellular parasite in the blood of vertebrates. It is widely distributed in tropical & temperature countries of world but they are no longer a problem in colder countries of the world. Countries like India, Sri-Lanka, Bangladesh Nepal & Pakistan etc are worst affected. In India state like Bihar & Uttar Pradesh suffer a great setback by the infection of this parasite. In fact the infection of plasmodium is a global problem

Monocystis:-

Classification:

Phylum: Protozoa

Subphylum: Plasmodroma

Class: Sporozoa

Subclass: Telosporidia

Order: Gregarinida

Genus: *Monocystis*

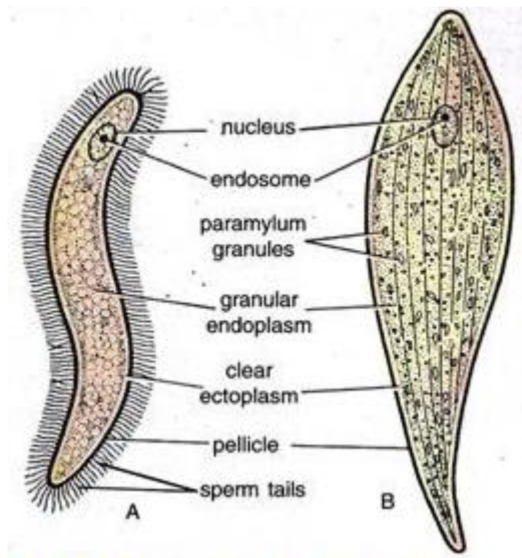


Fig. 1.10 Monocystis

Comments:-

- The trophozite (vegetative phase of *Monocystis*) is elongated, flattened, club-shaped and pointed at both ends of the body
- The body of trophozoite is covered with a firm pellciel.
- The cytoplasm is distinctly divided into a dense superficial ectoplasm and a central semifluid mass. The endoplasm.
- Ectoplasm contains the myonemes, while the endoplasm contains large nucles and the reserve food material in the form of paramylum.
- Contractile vacuole, mouth, gullet, cilia and flagellum are absent.
- Nutrition is affected entirely by the absorption of fluid juice of the host through the surface.
- Reproduction by spore formation.
- Life cycle is completed within a single host.

Habit and habitat:-

- *Monocystis* is a parasite living in the seminal vesicles of earthworm.

Distrution:

- *Monocystis* is cosmopolitan in distribution.

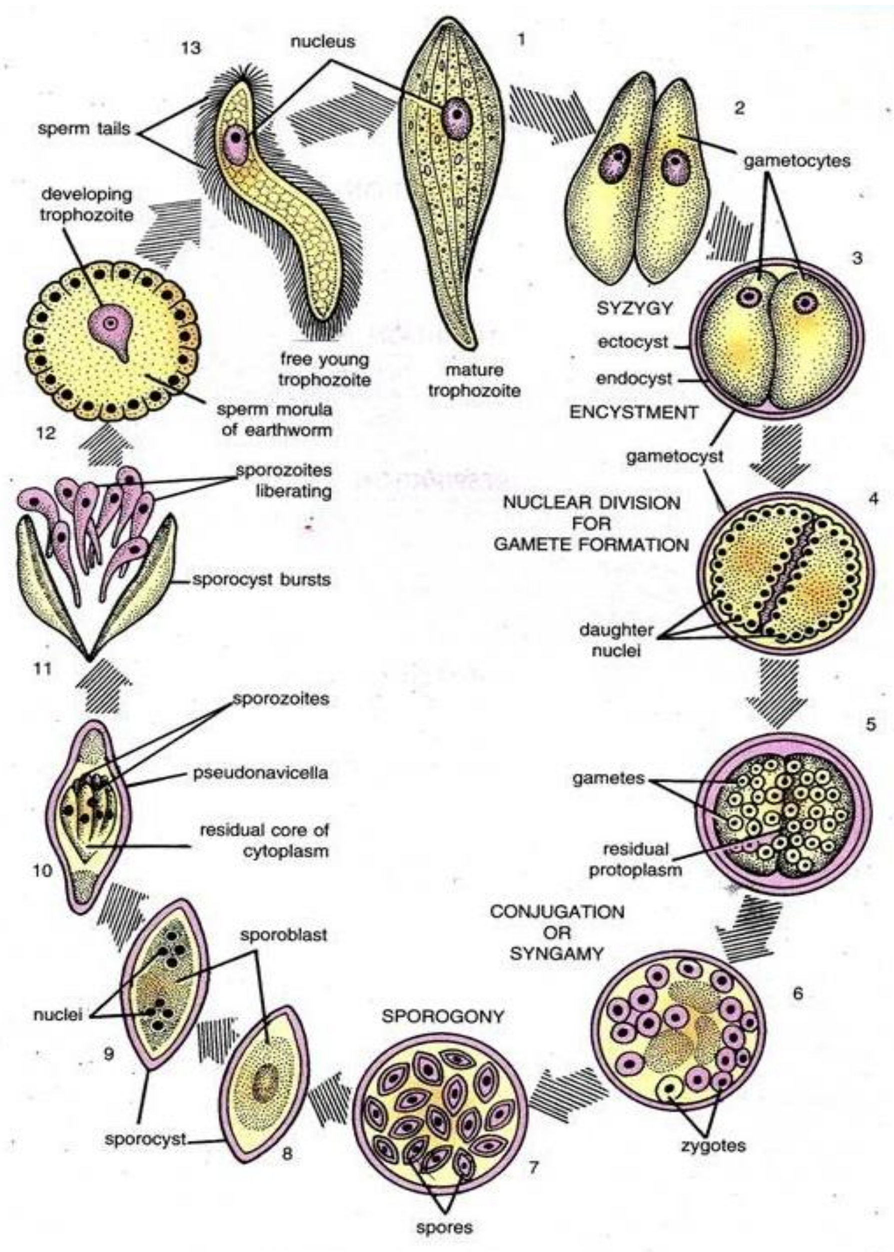


Fig.1.11 Life history of Monocystis

Monocytis is a parasite and its spore is probably released from the seminal vesicles of earthworm by the death and decay of earthworm. Each spore containing eight sporozoites which are released from the spore following the ingestion by another worm and action of its digestive juices on the spore.Two trophozoit come together and are surrounded by a common two layered cyst wall and are known as gametocytes. And each trophozoites then divides producing a number of small cells called gametes and these gametes are finally unite together in a pair form the Zygote and these zygote become lemon shaped and secrete a thin hard wall about itself which is known as sporoblast.

1.3.6: Study of Leishmania, Entamoeba & Giardia:

Leishmania:-

Classification:-

Phylum: Protozoa

Subphylum: Sarcomastigophora

Class: Zoomastigophorea

Order: Kinetoplastida

Family: Trypanosomatidae

Genus: *Leishmania*

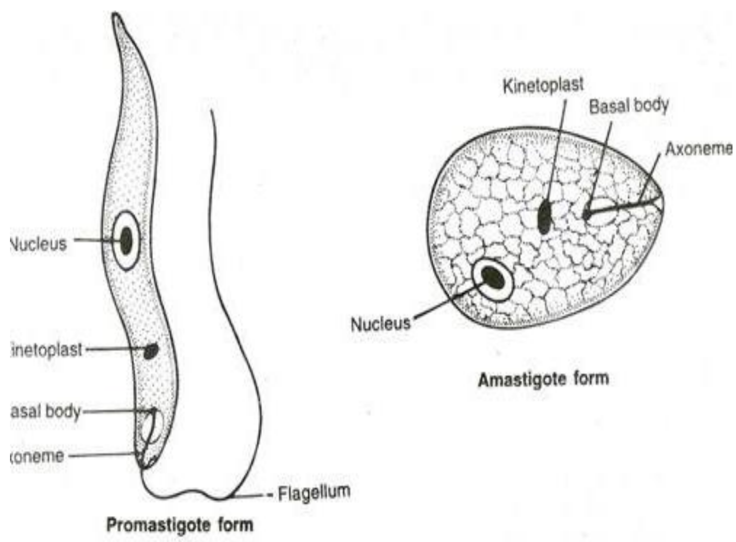


Fig. 1.12 Leishmania

Distribution:-

It is found as an intracellular parasite in Leucocytes and cells of liver, spleen, bone marrow, etc.

Morphology and Life Cycle:-

- *Leishmania* spp. are digenetic or heteroxenous parasites, whose life cycle involves two
- Hosts, a vertebrate and an invertebrate, the sandfly
- Hemoflagellates may have several morphological stages that differ from one another in the placement of the kinetoplast relative to the nucleus, as well as the location and origin of the flagellum3

- In *Leishmania* the life cycle stage in the vertebrate is the amastigote and in the insect, the promastigote. *Leishmania* exist in two basic body forms

  (a) The amastigote, the intracellular form in the vertebrate host, and

  (b) promastigote, the extracellular form in the sandfly (*Phleobotomus* spp and *Lutzomyia* spp.) Vector
- Amastigotes are taken up from the blood of an infected host when the female sandfly bites, and in the sandfly gut they develop into promastigotes where they multiply by binary fission; promastigotes move anteriorly into the proboscis, and are introduced into the vertebrate host when the sandfly bites again. 5
- The promastigotes injected by the sandfly during feeding are phagocytized and develop into intracellular amastigotes.
- The amastigote, literally "without a flagellum," is the intracellular, non-motile form in the vertebrate host, and it divides by longitudinal binary fission at 37^{o}C. Intracellular zamastigotes are 3-6 um in length and 1.5-3.0 um in width.7
- The amastigote is also called the Leishman-Donovan (LD) body. The amastigote is not really devoid of a flagellum, it is simply that the flagellum does not protrude beyond the body surface and by light microscopy cannot be seen.

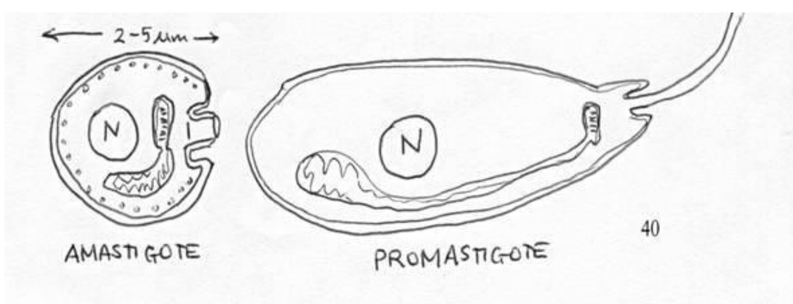


Fig.1.13 different stage of Leishmania

- The promastigote, literally the body form with "an anterior flagellum" is 15-30 um in body length and 5mm in width.

- it is extracellular, motile, and grows and divides by longitudinal binary fission at 27^{o}C in the sand.

- Promastigotes can be grown in vitro at 25^{o}C temperature on NNN medium, which has a solid phase of blood agar and a liquid phase containing a physiologic salt solution. Liquid media that support promastigote growth are also available.

- Amastigotes usually are grown inside tissue culture cells and can also be grown extracellularly at 37^{o}C under special conditions

Leishmania donovani is a digenetic parasite passing its life cycle in two different hosts.

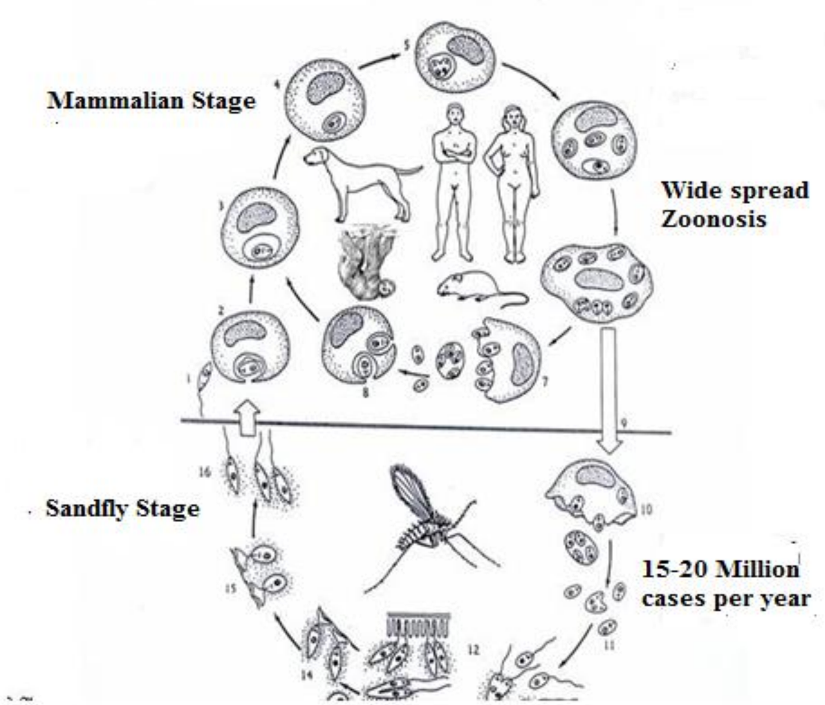


Fig.1.14.Digenetic Life Cycle of Leishmania

DEFINITIVE HOST:

In humans the metacyclic promastigotes are injected by sandfly through the skin during its blood meal. When sandfly bites using its proboscis it rejects the parasites that are stored inside the hollow tube. Some promastigotes may enter the blood stream directly where some are destroyed by macrophagic cytolysis. But many are also taken up through phagocytosis by mononuclear phagocytes in liver, spleen and bone marrow. Inside the cells they undergo spontaneous transformation into oval-shaped amastigotes. Granulocytes selectively kill the promastigotes by oxidative mechanism; while amastigotes are resistant .Then the surviving amastigotes undergo cell division using simple binary fission. Multiplication continues until the host cell can no longer hold and ruptures. In a fully congested cell there can be as many as 50 to 200 amastigotes, which are released into tissue cavities. Each individual amastigote is then capable of invading fresh cells. As a result, the entire tissue is progressively infected and destroyed. A number of free amastigotes then enters the blood stream where many are phagocytosed by macrophages. These free and phagocytosed amastigotes in peripheral blood are then sucked up by blood-feeding sandfly.

INTERMEDIATE HOST:

L. donovani undergo further development only in the digestive tract of the female sandfly. Hence only females are responsible for transmitting the infection. Once the amastigotes are ingested, they enter the midgut of the sandfly. Then they undergo structural modification into flagellated promastigotes, becoming larger and considerably elongated. They get attached to the gut epithelial lining where they multiply rapidly by binary fission. (They are also capable of sexual reproduction by genetic hybridisation in the sandfly gut.) They then migrate back towards the anterior part of the digestive system such as pharynx and buccal cavity. This process is known as anterior station development, which is unique in *Leishmania.* A heavy infection of pharynx can be observed within 6 to 9 days after initial blood meal. The promastigotes become infective only by this time, and the event is called the metacyclic stage the metacyclic promastigotes then enter the hollow proboscis where they accumulate and completely block the food passage. Immediately upon biting a human, the parasites are released, which invariably results in infection. The stages of development in sandfly can be described as follows:-

1. Soon after entering the gut, the amastigotes get coated with peritrophic matrix, which is composed of chitin and protein complex. This protects the parasites from the digestive enzymes of the host.
2. The amastigotes travel as far as the abdominal midgut and first transform into a weakly motile "procyclic promastigotes" on the gut wall within 1–3 days.

3. The young promastigotes secrete a neuropeptide that stop peristalsis of the gut. The surface lipophosphoglycan (LPG) of the promastigote serves as an attachment to the gut epithelium. These factors prevent the expulsion of promastigotes during excretion of the Insect.

Symptoms of the Disease:-

Different species of Leishmania, diseases cause y them and the symptoms are:

1 L.donovan: cause **Kala Azar** or **dum dum** fever:Darking of skin,enlargement of spleen and liver , fever and anaemia..

2 L.tropica cause **OrientalSores**: disfiguration of ear,face,fore arms and legs.

3 *L.brasiliensis*: Cause **American Lishmaniasis**: inflammation of mucous membrane of nose and throat and enlargmen of spleen and liver, spleen lymph nodes etc.

Mode of transmission:

All species are transmitted by small blood-sucking sandflies, notably *Phlebotomus* spp. in the Old World and *Lutzomyia* spp. in the New World. Only the females feed on blood. Amastigotes ingested during feeding transform in the midget or hindgut into promastigotes which multiply by binary fission. The parasites migrate forward to the foregut and proboscis where some become swept away by saliva into the bite site when the fly feeds.

Treatment:-

- Some cutaneous infections require no treatment as lesions may heal within several months.
- Systemic therapy with pentavalent antimonials (sodium stibogluconate or meglumine antimonate) is the treatment of choice for disfiguring and visceral infections.
- The development of antimonial drug resistance, however, is a growing problem in many endemic areas, including South America, India and the Middle-East. Pentamidine or amphotericin B can be used if antimonials are ineffective, and miltefosine and aminosidine (paromomycin) have shown promise as treatment options, especially when combined with immunotherapy using the tumour-necrosis factor-alpha (TNF-?) inhibitor pentoxifylline.

Control:-

- Preventive measures include protection from sand fly bites but this can be difficult as they are so small that they can penetrate most mosquito nets. Reducing the size of reservoir host populations (especially dogs) has proven beneficial in many endemic urban areas.
- Cutaneous infections, however, are acquired in forests away from human habitation, as the reservoir hosts are wild animals (esp. rodents). The prevention of sand fly bites in forest areas is almost impossible but may be minimized by the use of protective clothing, insect repellants and insecticidal sprays in houses.
- Killing of reservoir hosts like infected street dogs.

ENTAMOEBA HISTOLYTICA

CLASSIFICATION

Phylum	protozoa
Sub phylum	Sarcomastigophore
Class	Rhizopoda
Order	Lobosa
Genus	*Entamoeba*
Species	*histolytica*

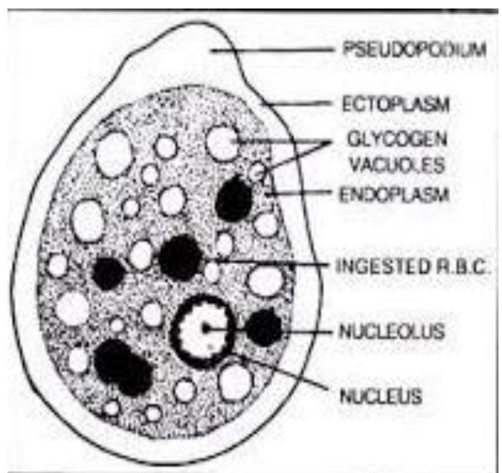


Fig. 15 Entamoeba histolytica

Distribution:-

Entamoeba histolytica is worldwide in distribution, but its prevalence is greater in tropics and subtropics than in the temperate zones. It has been reported that incidence of infection is high in Mexico, China, India and parts of South America.

Habits and Habitat:-

Entamoeba histolytica is a microscopic endoparasite of man .it is commonly found in the upper part of the large intestine and is very often lodged in the river, lungs, brain and testes.

Commment:-

- *Entamoeba histolytica* is a small microscopic parasitic *Amoeba* .in its life cycle, it occur in three distinct forms.
- Trophozoite or magna form.
- Precystic or minuta form.
- Cystic forms.

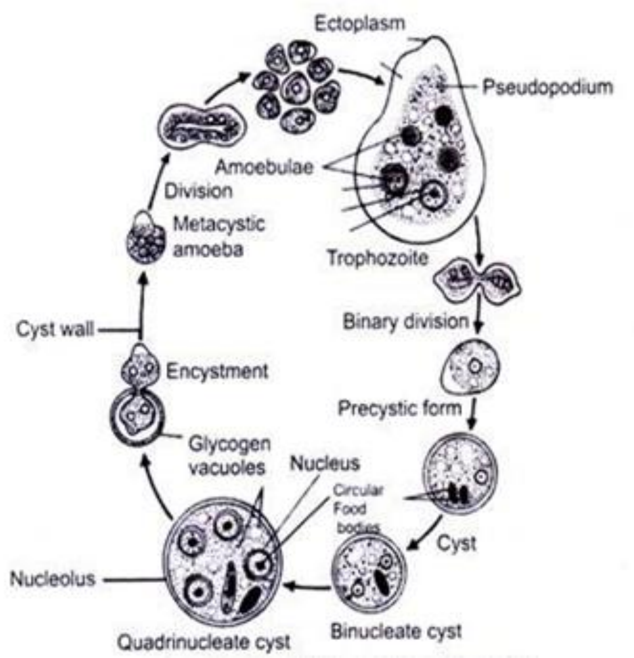


Fig.16 Lifecycle of E. histolytica

Trophozoite:

This stage is disease causing.

- This is growing stage measuring 18 – 30 microns in size.
- Cytoplasm is divided into clear hyaline ectoplasm and granular endoplasm.
- A dot shaped karyosome is present in the centre of the nucleus .the nuclear membrane is lined with chromatin granules.

- Mitochondria are absent an respiratory enzymes are present along the endoplasmic reticulum
- Nutrition is holozoic and its feeds on the cells of the intestinal wall.

Pre Cystic stage

1. Trophozoites multiply asexually by binary fission within the wall of large intestine. Some of the daughter cells invade fresh host cells while others become pre cystic or minute forms.
2. Pre Cystic forms are smaller in size with blunt pseudopodia; endoplasm is free of red blood cells and other ingested food particles.
3. Nucleus is like the Trophozoite stage.

Cystic stage:-

1. In the lumen of the intestine pre cystic or minute forms round up and secrete a tough but flexible cyst wall around them.
2. The single nucleus in the cyst undergoes two mitotic divisions to form a tetra nucleate cyst.
3. Tetra nucleate cysts are the infective stage .they pass out with stools.

HOST:-

Entamoeba histolytica is found in the colon region of the large intestine as an endo parasite .it can also lodge in the river, lungs, brain and testes.

Symptoms of the disease

1. *Entamoeba histolitica* causes amoebiasis in man.
2. It invades the mucosa and sub mucosa layers in the large intestine and causes ulcers which later forms abscesses.
3. Blood, mucous, cell debris and swarms of entamoeba are given out with the stool

   And Trophozites enter the blood circulation and reach liver, lungs, brains and gonads where they erode tissues a forms abscesses which can at a time prove fatal.

Mode of transmission:-

1. It occurs by ingestion of food or water contaminated with faecal matter

Treatment:-

Drugs likes Emetine, Vioform, Terramycin and Metronidazole are known to be effective.

Prevention:-

Hygenic handling of food and water and municipal hygine are necessary to prevent infection by Entamoeba histolytica.

Giardia:-

Classification

Phylum Protozoa

Subclass Sarcomastigophora

Class Zoomastigophorea

Order Diplomonadida

Genus *Giardia*

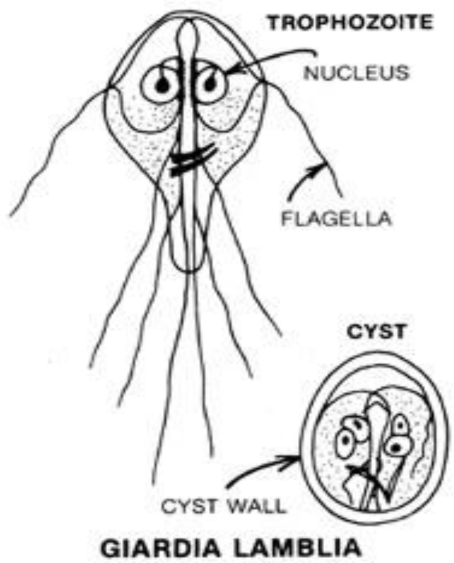


Fig.17 Giardia

Comments:-

- It is live in the intestine of man as an endoparasite and cause **Giardiasis**
- It has two nuclei and bears four flagella on either side of the body
- Its fee on vitamins and amino acids contained in food within the intestine.
- Giardia intestinalis trophozoites are pear-shaped and 10–20 µm long.
- Other characteristics include: flagella, median bodies, sucking disks and two big nuclei. Giardia intestinalis cysts are oval to ellipsoid and 8–19 µm long
- Immature cysts have two nuclei, whereas mature cysts have four.

Causal Agent:-

Giardia intestinalis is a protozoan flagellate (Diplomonadida). This protozoan was initially named *Cercomonas intestinalis* by Lambl in 1859. It was renamed *Giardia lamblia* by

Stiles in 1915 in honor of Professor A. Giard of Paris and Dr. F. Lambl of Prague. However, many consider the name, *Giardia intestinalis*, to be the correct name for this protozoan. The International Commission on Zoological Nomenclature is reviewing this issue.

Life Cycle:-

Cysts are resistant forms and are responsible for transmission of giardiasis. Both cysts and trophozoites can be found in the feces (diagnostic stages)

- The cysts are hardy and can survive several months in cold water. Infection occurs by the ingestion of cysts in contaminated water, food, or by the fecal-oral route (hands or fomites)
- In the small intestine, excystation releases trophozoites (each cyst produces two trophozoites)
- Trophozoites multiply by longitudinal binary fission, remaining in the lumen of the proximal small bowel where they can be free or attached to the mucosa by a ventral sucking disk.
- Encystation occurs as the parasites transit toward the colon. The cyst is the stage found most commonly in non-diarrheal feces.
- Because the cysts are infectious when passed in the stool or shortly afterward, person-to-person transmission is possible. While animals are infected with *Giardia*, their importance as a reservoir is unclear.

Host:-

It inhibits the intestine of man and other vertebrates like rat, rabbit, dog, cat etc.

Symptoms:-

- Bad breath and farts.
- Dehydration.
- Diarrhea or greasy floating stools.
- Fatigue.
- Loss of appetite.

- Nausea & Stomach ache
- Weakness

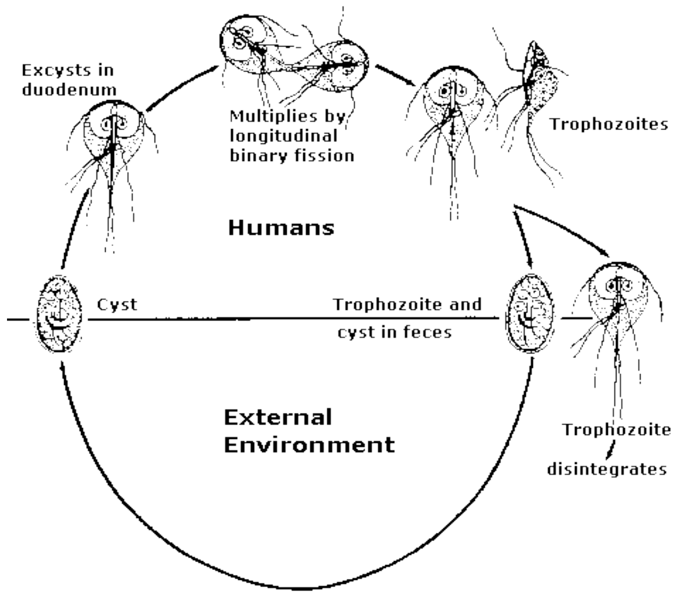


Fig.18 Life cycle of Giardia

Diarrhea can be fatal, if you do not drink enough water with salt and glucose. Another not so recognizable effect is the lack of B12-vitamin. This is due to the impaired absorption (malabsorption) in the damaged intestinal wall. 50 % of giardiasis cases are asymptomatic. Symptoms begin usually within two weeks after becoming infected. In healthy individuals the sickness normally persists up to three weeks, but sometimes longer

Diagnosis:

By examining stool samples under a microscope. Common microscopical techniques include: wet mount with iodine, trichrome or immunofluorescent antibody staining and/or enzyme immunoassays. Several stool samples are usually needed on different days because cysts and trophozoites are not always present in the feces. Trophozoites can also be found from duodenal fluid or from biopsies taken during endoscopy.

Mode of Transmission:-

It occurs by ingestion of food or water containing protozoan cysts. It is transmitted by unprotected sexual intercourse.

Treatment:

It accomplished with antimicrobial drugs such as: metronidazole, nitazoxanide (good for treating children), tinidazole, paromomycin, quinacrine and furazolidone.

Prevention:

Prevention is achieved by protected sexual intercourse and good personal hygiene.

1.7- References:-

1. Poddar T., Mukhopadhya S., Das S.K (2015) an advanced laboratory Manual of Zoology.

2. Verma P.S., (2014) A manual of practical Zoology, Invertebrates.

3. Rastogi V.B. (1999) Lower non-chordate & Economic Zoology.

UNIT: 02 PORIFERA

General Characters:-

1. Animals belonging to phylum Porifera are commonly called **Sponges** as these bear pores i.e. they are porous.
2. Sponges are **sessile** animals which remain attached to rocks, shells or other substrata, growing like plants.
3. Sponges are marine organisms distributed from Arctic to Tropic seas except those belonging to family Spongillidae , distributed in freshwater.
4. Body shape is cylinder or vase like, **assymetrical or radially** symmetrical.
5. Sponges are **multicellular** organisms having **diploblastic** body consisting of outer layer of **ectoderm**, inner **endoderm** and an intermediate **mesenchyme**.
6. **Spongocoel** is the internal space of the body which is either hollow or permeated by numerous canals lined with **choanocytes** (collared flagellated cells).

7. **Canal system** is present which helps in nutrition, respiration, excretion and reproduction in sponges.
8. Mouth is absent and digestion is **intracellular**.
9. Skeleton consists of **spicules** (calcareous or siliceous) or **fibres** (spongin).
10. Asexual reproduction (by buds and **gemmules**) as well as sexual reproduction (by ova and sperms) takes place in sponges.
11. Fertilization is internal, **holoblastic** cleavage, indirect development including freee-swimming ciliated larval stage called **Amphiblstula or Parenchymula**.
12. Sponges exhibit great power of **regeneration.**

Classification

PHYLUM-PORIFERA

Class

1. CALCAREA
   - Skeleton consisting of calcareous spicules.
   - Canal system may be Asconoid, Syconoid or Leuconoid

2. HEXACTNELLIDA
   - Skeleton consisting of six rayed triaxon siliceous spicules.
   - Sycon type canal system

3. DEMOSPONGIAE
   - Skeleton consisting of siliceous spicules or spongin fibres or both.
   - Leuconoid type canal system

Order1. Homocoela

- Asconoid sponges.
- Radially symmetrical, cylindrical body

  Examples: *Leucosolenia*, *Clathrina*.

Order 2. Heterocoela

- Syconoid or leuconoid sponges
- Vase shaped body

  Examples: *Sycon* or *Scypha*, *Grantia*.

Class 2. Hexactinellida

Orders ↓

Order1.Hexasterophora

- Spicules are hexasters (star like).
- Attached to hard objects without root tufts

Examples: *Euplectella*, *Farnera*.

Order 2. Amphidiscophora

- Spicules are amphidiscs.
- Attached to substratum by root tufts.

Example: *Hyalonema, Pheronema*.

Class 3. Demospongiae

Orders ↓

Order1. Myxospongida

- Simple structure.
- Skeleton absent

Examples: *Oscarella, Halisarca.*

Order 2. Tetractinellida

- Tetraxon spicules.
- Spongin present

Examples: *Chondrilla, Chondrosia*.

Order 3. Monoaxonida

- Monoaxon spicules
- Found in abundance throughout the world in freshwater and marine environment.

Examples: *Spongilla, Tethya, Cliona, Chalina, Microciona.*

Order 4. Keratosa

- Skeleton consisting of spongin fibres only.
- Body is rounded and massive.

Examples: *Euspongia, Hippospongia*.

2. 3- Leucosolenia:-

2.3.1 General Characters:

1. It is a marine colonial sponge inhabiting shallow waters below tide mark, not found in calm water. It is abundant in Northern Atlantic Coast and very common in Europe.
2. The colony of *Leucosolenia* is whitish yellow in colour consisting of vase like simple or branching bodies about 25 mm long, joined together by horizontal tubes at the base.
3. The body surface is perforated by numerous pores called **Ostia** or incurrent pores through this water enter the body of sponge.
4. Each vertical tube terminates into **osculum** at distal end through which water moves out of the body of sponge.
5. Calcareous spicules are **monoaxon** (spicules growing along single axis) or **triaxon** (spicules consisting of three axes crossing at right angles) type.
6. Simplest type of canal system *i.e.* **Ascon type** the course taken by water current is:

   $$\text{Ingressing water} \xrightarrow{\text{Through Ostia}} \text{Spongocoel} \xrightarrow{\text{through Osculum}} \text{To outside}$$

7. Asexual reproduction by **Branching** and **Budding**.
8. Sexual reproduction by ova and spermatozoa, indirect development including **Paranchymula larva**.

2.3.2 Identifying character:

Presence of osculum, Ostia and colonial structure.

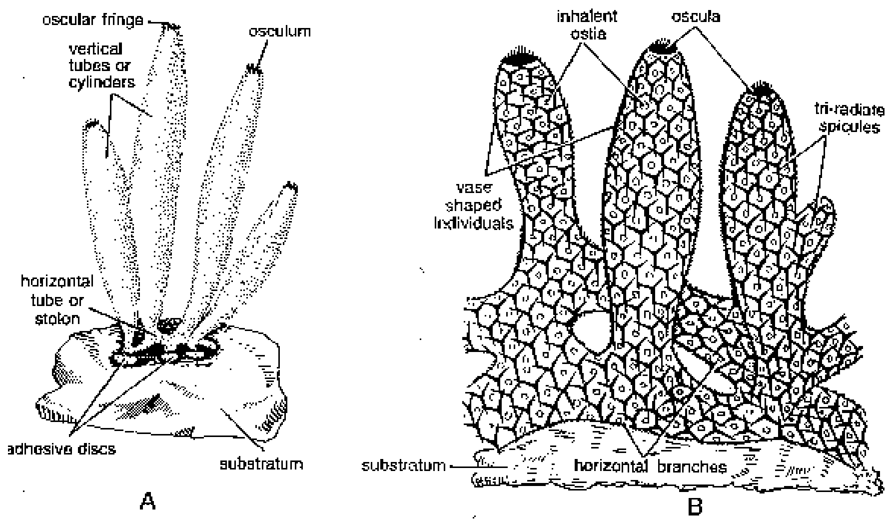


Fig.2.1 A. Colony B. Portion of colony (magnified)

2.3.3- Systematic Position:-

Phylum............Porifera (Porous body, cellular grade of body Organization, radially symmetrical).

Class...............Calcarea (Skeleton having calcareous spicules)

Order ....Homocoela (Ascon type canal system)

Genus ....*Leucosolenia*

2.4 Grantia:-

2.4.1 General Characters:-

1. It is a marine sponge found attached to substratum in shallow and well oxygenated waters, distributed in Europe.
2. Body is slender; vase- shaped measuring about 20-25 mm in length and 5-6 mm in diameter.
3. **Osculum** is present at the distal end of each cylindrical tube. It is encircled by a fringe of large monoaxon spicules forming an **oscular fringe**.
4. The **dermal membrane** spreads over the entire surface of sponge forming a cortex, provided with special **cortical spicules** arranged parallel to the surface.

5. Due to the development of **cortex,** incurrent passages become more irregular and branching and **subdermal spaces** may be present
6. **Syconoid** type canal system. water current passes through ostia → incurrent canal → prosopyles → radial canal → apopyles → spongocoel → osculum → exterior

Reproduction takes place by sexual as well as asexual methods.

2.4.2- Identifying character:-

Identifying characters are similar to *Sycon* except the presence of dermal membrane spreading over the entire surface of sponge forming a cortex.

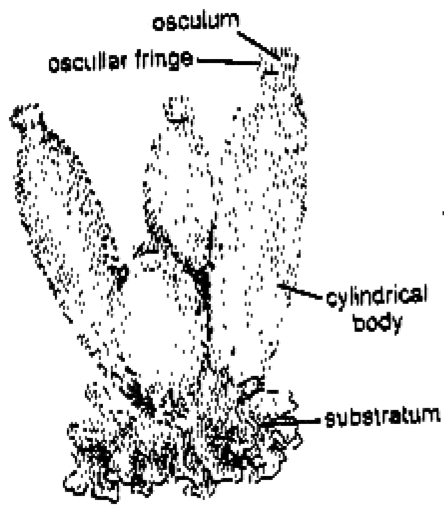


Fig.2.3 *Grantia*

2.4.3- Systematic Position:-

Phylum............Porifera (Porous body, cellular grade of body organization, radially symmetrical)

Class...............Calcarea (Skeleton having calcareous spicules)

Order ....Heterocoela (Sycon type canal system)

Genus ....*Grantia*

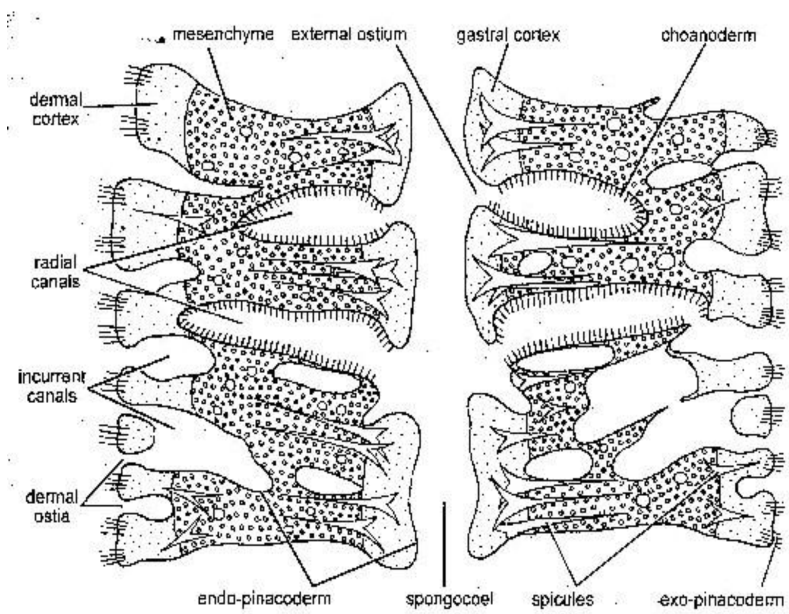
2.4.4 (a) L.S. of *Grantia:-*

Comments: L.S. of *Grantia* shows the following histological features:

1. Cellular grade of organization and **diploblastic** pattern is visible.

2. Body wall differentiated into outer **ectoderm**, intermediate **mesenchyme** and inner **endoderm** cells.
3. Ectoderm or dermal epithelium is made up of spindle shaped cells called **Pinacocytes**.
4. Entire surface is covered by dermal membrane forming **cortical zone** having cortical spicules. Presence of cortical zone is the only difference between *Sycon* and *Grantia*.
5. Mesenchyme is a gelatinous matrix containing **amoebocytes, archaeocytes, germ cells, gland cells, scleroblast cells, collenocyte cells** and **spicules**.
6. Endoderm forms lining of radial canal having **choanocyte cells.** These are flagellated collar cells which maintain the water current inside the body due to the beating of flagella
7. **In current canals** are channelized, branched and irregular due to the development of **dermal cortex.**
8. **Radial canals** are also branched and irregular.
9. **Spongocoel** is lined with gastral cortex.
10. **Syconoid** type canal system. water current passes through ostia → incurrent canal → Prosopyles → radial canal → apopyles → spongocoel → osculum → exterior.

Identifying character: Presence of dermal cortex, irregular radial canals and, in current canals.



2.3.4 (a) L.S. of *Grantia*

2.4.4 (b) T.S. of *Grantia:-*

Comments: T.S. of *Grantia* shows the following histological features:

1. **Diploblastic** body wall.
2. Body consisting of outer **ectoderm**, inner **endoderm** with an intermediate **mesenchyme**.
3. Dermal membrane forms **dermal cortex** covering the entire surface of the body.
4. **Ostia** open into **incurrent canal** which communicate with radial canal by **prosopyle**.
5. **Radial canals** containing **choanocytes** open into spongocoel by **apopyle**.
6. **Spongocoel** is lined with gastral cortex.
7. **Syconoid** type canal system. water current passes through ostia → incurrent canal → prosopyles → radial canal → apopyles → spongocoel → osculum → exterior.

Identifying character: Presence of well developed dermal cortex and incurrent canals arranged in circular manner.

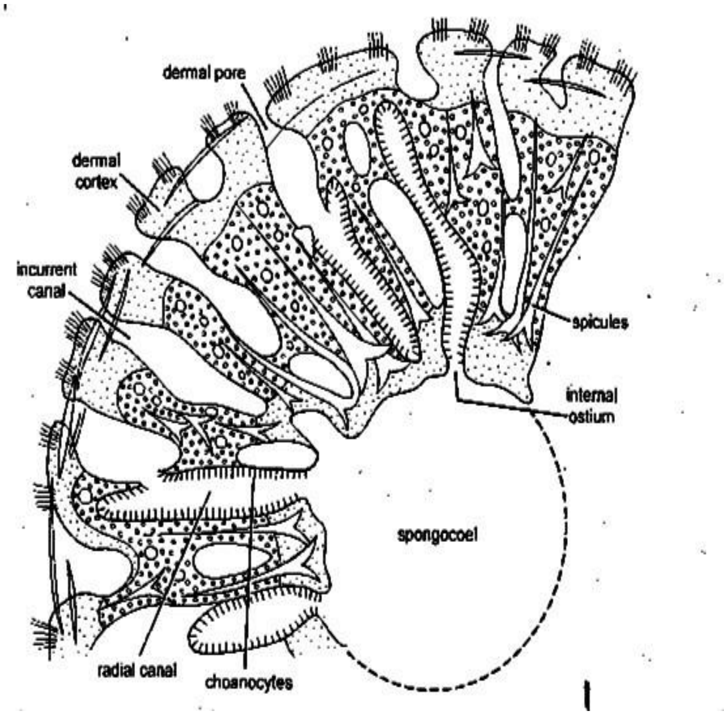


Fig. 2.3.4 (b) T.S. of Grantia

2.5 - Sycon or Scypha:-

2.5.1 General Characters:-

1. Scypha is commonly called **Crown sponge**.
2. It is a small, solitary or colonial marine sponge found in shallow and well oxygenated water. Commonly distributed in Europe from Rhode Island to Greenland.
3. Body is vase-shaped (measuring 20-25 mm in length) opening to exterior by **osculum** at distal end.
4. **Osculum** is encircled by **oculars fringe** formed by **monoaxon spicules.**
5. Proximal end or **base** is attached to the substratum.
6. Body wall is thick having **monoaxon, triaxon** and **tetraxon** spicules.
7. Body wall consists of outer **dermal epithelium** and inner **flattened epithelium** which lines the spongocoel separated by a middle layer of mesenchyme.
8. Canal system is **syconoid type**. Water current passes through Ostia → incurrent canal
   Prosopyles → radial canal → apopyles → spongocoel → osculum → exterior.
9. Reproduction by asexual (**budding**) as well as sexual method.
10. Larval stage is called **amphiblastula**.

2.5.2- Identifying character:

Presence of oculars fringe and Ostia.

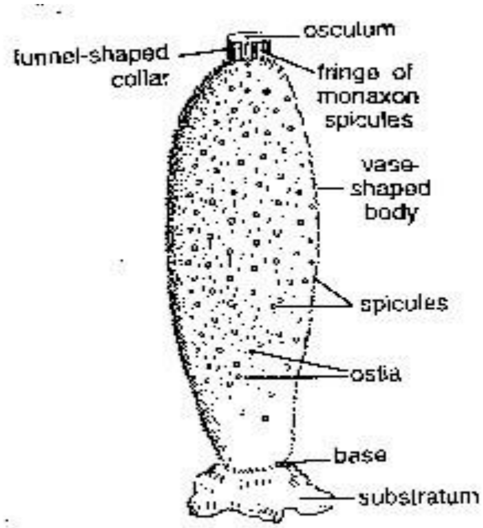


Fig. 2.2 Scyon or Scypha

2.5.3- Systematic Position:-

Phylum............Porifera (Porous body, cellular grade of body organization, radially symmetrical)

Class...............Calcarea (Skeleton having calcareous spicules)

Order ....Heterocoela (Sycon type canal system)

Genus ....*Sycon or Scypha*

2.5.4 - T.S. and L.S of *Scypha*

Comments: T.S. of *Scypha* shows the following histological features:

1. Body layers are **diploblastic**, showing **cellular organization**.
2. Outer **ectoderm,** inner **endoderm** and intermediate **mesenchyme** are present.
3. Ectoderm consists of **pinacocytes** which form the lining of incurrent canals.
4. Gelatinous mesenchyme having calcareous spicules, amoeboid cells, collenocytes, archaeocytes etc is present.
5. Endoderm consists of flagellated choanocyte cells forming the lining of **radial canals**.
6. Radial canals are alternately arranged with **incurrent canals** which are connected to each other by **prosopyle**.
7. Radial canals open into the **spongocoel** by **apopyle** (internal ostium)
8. In T.S. of *Sycon* finger like projections of flagellated chambers arranged in a characteristic circular manner is visible.
9. Canal system is **Syconoid** type and flow of water current is same as described above.

Identifying character: Finger like flagellated radial canals alternating with incurrent canals in a circle.

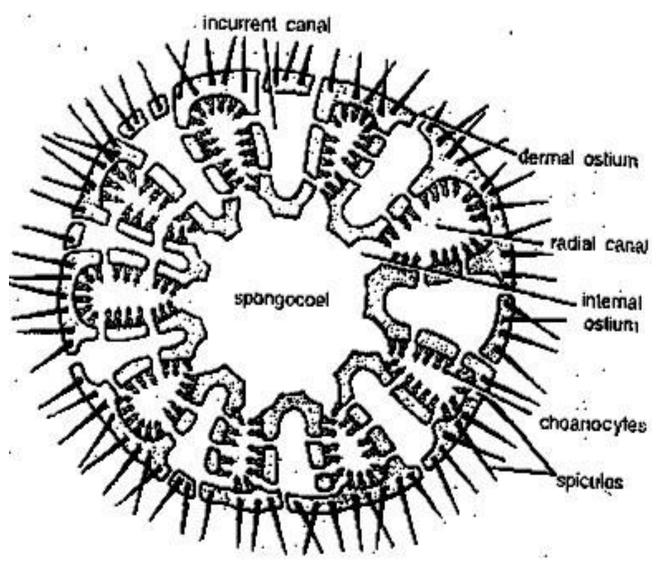


Fig. 2.2.4 (a) - T.S. of Scypha

L.S. of Scypha:-

Comments: L.S. of *Scypha* shows the following histological features:

1. **Diploblastic** body wall consisting of ectoderm, mesenchyme and endoderm.
2. **In current canals** (lined with dermal epithelium) and **radial canals** (lined with choanocytes) alternate with each other.
3. **Mesenchyme** forms intermediate layer containing amoebocytes, spicules etc.
4. **Spongocoel** is lined by flat epithelium.
5. **Prosopyle** forms connection between incurrent canal and radial canal and Apopyle is the opening of radial canal into spongocoel (lined by flat epithelium).
6. Canal system is **syconoid type**.

Identifying character: Finger like radial canals without dermal cortex alternating with incurrent canals.

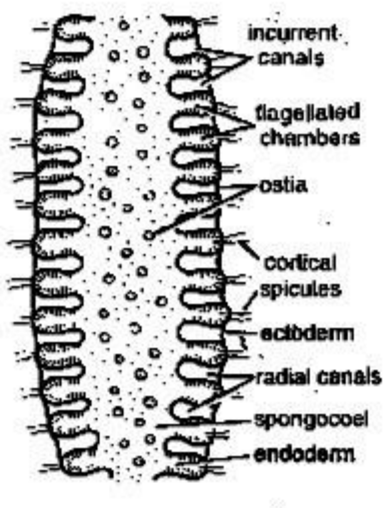


Fig. 2.2.4 (b) - L.S. of Scypha

2.5– *Hyalonema:-*

2.5.1 General Characters:-

1. *Hyalonema* is commonly called **glass rope sponge** as it appears like ball of glass wool with projecting tufts of **glassy spicules**.
2. It is a marine sponge inhabiting 10-15 metres deep sea water. It is found along the New England coast.
3. Body is round or oval and **radially symmetrical**.
4. The spicules of **root tuft** are compact, elongated and twisted forming an axis or **columella**. It helps the organism in anchoring.
5. Several polyps of a Zoanthidea (anemone) grow in **symbiotic** association with *Hyalonema* at its columella.
6. **Osculum** contains a **sieve plate**.
7. **Spongocoel** can be noticed only when the upper surface of the sponge body is depressed since the excurrent canals open into it, but when the surface is extended into a gastral cone by upward projection of columella, no spongocoel exists.
8. Skeleton consists of small **amphidiscs**. Whole body is covered by small branching six rayed spicules which resemble to Christmas trees.

2.5.2- Identifying character:-

Presence of glossy root spicules tuft, large osculum containing sieve plate and symbiotic polyps.

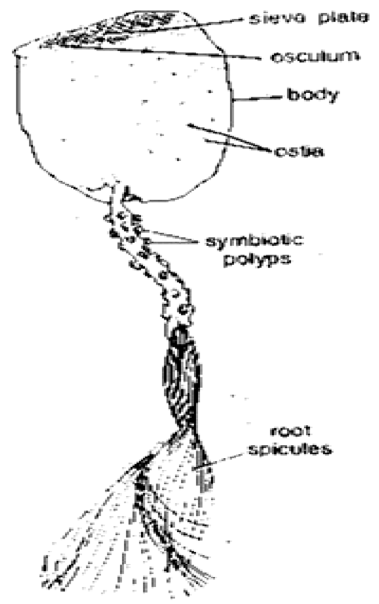


Fig.2.4 *Hyalonema*

2.5.3 Systematic Position:-

Phylum............Porifera (Porous body, cellular grade of body organization, radially symmetrical)

Class..............Hexactinellida (Skeleton having, six rayed triaxon siliceous spicules)

Order ....Amphidiscophora (Spicules are amphidiscs)

Genus ....*Hyalonema*

2.6 – *Euplectella:-*

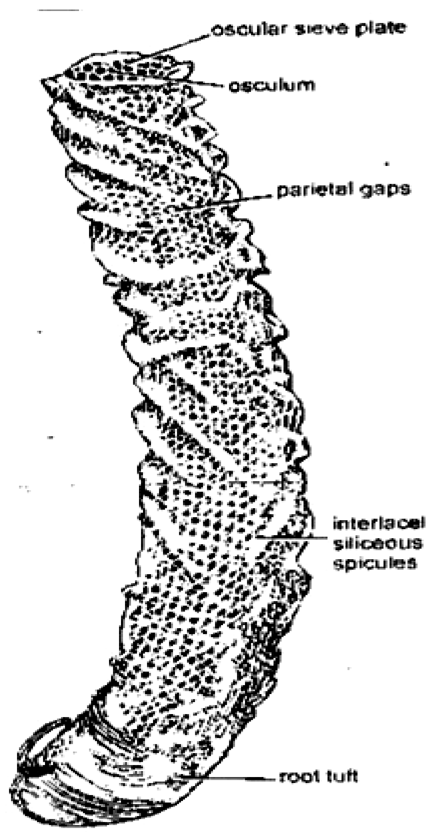


Fig.2.5 Euplectella

2.6.1 General Characters:-

1. It is commonly called **Venus's flower basket** as it appears like knitted elongated basket.
2. *Euplectella* is a **solitory** sponge inhabiting deep sea waters (500-5000 m) distributed near Philippines and West Indies. It measures 15-30 cm in length and 2-5 cm in diameter.
3. Body is long, curved and cylindrical which is fastened in the mud of sea bottom.
4. **Six rayed** siliceous spicules are present which fuse at their tips to form a three dimensional network with **parietal gaps**.
5. At the lower end **root tuft** is formed by long siliceous spicules. It helps *Euplectella* to anchor in the mud.
6. **Oscular sieve plate** is present above the osculum.
7. Canal system is **sycon** type.

8. *Euplectella* shows an interesting feature. It possesses a pair of shrimp imprisoned within its skeleton. This is given as a wedding gift in Japan to signify a close relationship.

2.6.2- Identifying character:-

Knitted basket shaped body, Ostia and oculars sieve plate.

2.6.3- Systematic Position:-

Phylum............Porifera (Porous body, cellular grade of body organization, radially symmetrical)

Class.............Hexatinellida (Skeleton having, six rayed triaxon siliceous spicules)

Order ....Hexasterophora (Spicules are hexasters *i.e.* star like)

Genus ....*Euplectella*

2.7 – *Spongilla:-*

2.7.1 General Characters:-

1. *Spongilla* is commonly known as **fresh-water sponge** as it is found in freshwater ecosystems in Atlantic, Europe and American waters.
2. It is present in the form of profusely **branched colony**.
3. It exhibits greenish colour due to the presence of symbiotic algae like ***Zoochlorellae*** within the body.
4. Body wall consists of very thin **dermal membrane** perforated with dermal pores or **ostia** and several **oscula**.
5. Different types of **monaxon siliceous spicules** are present. They are of large (**megascleres**) and small (**microscleres**) size held together by **spongin fibre**.

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2.7.2- Identifying character:-

Branched colony, ostia and rhagon type canal system.

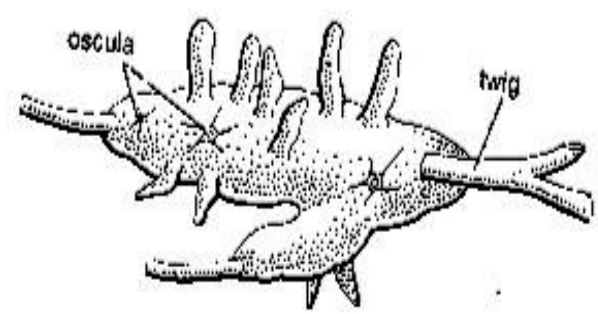

Fig.2.6 Spongilla

2.7.3- Systematic Position:-

Phylum............Porifera (Porous body, cellular grade of body organization, radially symmetrical)

Class.............Demospongia (Skeleton consisting of spongin fibres and siliceous spicules)

Order ....Monaxonida (Spicules are monoaxon)

Genus ....*Spongilla*

2.8 – *Euspongia:-*

2.8.1 General Characters:-

1. Commonly called **Bath Sponge.**
2. It is found on rocky bottoms in warm shallow sea water of Mediterranian, U.S.A., Asia and Australia.
3. Massive body with variable shape often globose, cup shaped or lamelliform.
4. Skeleton consists of network of **spongin fibres** without spicules.

5. Surface of the body contains large openings called **oscula** and small openings called **inhalent canals.**
6. Dried skeleton of Euspongia is used as a **bath sponge** as it consists of **spongin fibres** having the capacity hold a large amount of water.
7. It is used in offices for wetting postal stamps, paper, currency etc.

2.8.2- Identifying character:-

Oscula, inhalant canals and globose body with meshy spongin fibres.

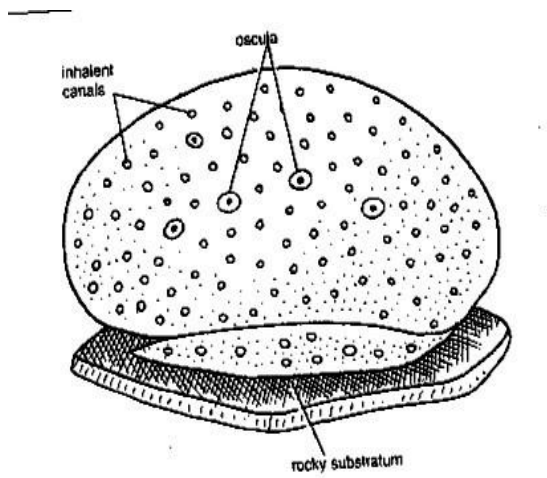

Fig.2.7 Euspongia

2.8.3- Systematic Position:-

Phylum............Porifera (Porous body, cellular grade of body organization, radially symmetrical)

Class.............Demospongia (Skeleton consisting of spongin fibres or siliceous spicules or both)

Order ....Keratosa (Skeleton of spongin fibres only spicules absent)

Genus ....*Euspongia.*

2.12 – References:-

Jordan, E.L., Verma, P.S. 2009: Invertebrate Zoology publ. S.Chand and Co. New Delhi, 1127 pp.

Verma, P.S. 2012: A Manual of Practical Zoology Invertebrates, 15th edition, publ. S.Chand and Co. New Delhi, 497 pp.

Lal, S.S. 2011: Practical Zoology Invertebrate, 10th edition, publ. Rastogi Publication, Meerut, 512 pp.

Kotpal, R.L. 2011: Modern Text Book of Zoology Invertebrates Rastogi Publication, Meerut. 883 pp.

2.13 - Suggested Readings

Edward, R and Barnes, R 1994: Invertebrate Zoology, 6th edition, Saunders College Publishing, Harcourt Brace And Co., Orlando, Florida, 1100pp.

Parker, T.J. and Haswell, W.A. 1897: A Textbook of Zoology. Publ. Macmillan And Co. Ltd. Vol I and II.

Answers

a) budding and regeneration b) Ascon c) *Hyalonema* d) Spongin fibres e) *Euplectella* f) *Hyalonema* g) Rhagon type h) Choanocytes i) Crown sponge j) *Euspongia*

UNIT 3: COELENTERATE

General Characters

1. Multicellular organisms with **tissue grade** of organization.
2. They are aquatic, mostly marine except a few freshwater forms like *Hydra*.
3. They are sedentary or free swimming, solitary or colonial.
4. They show **radial** or **biradial** symmetry with central **gastro vascular** cavity opening to exterior by mouth.
5. **Diploblastic** body consisting of outer layer of **ectoderm**, inner **endoderm** and an intermediate non cellular gelatinous mesogloea.
6. **Acoelomate** i.e. coelom is absent.
7. Mouth is encircled by **tentacles** bearing **nematocysts** (stinging cells) meant for capturing food, adhesion, offence and defense.
8. They exhibit the phenomenon of **polymorphism** i.e occurence of different types of individuals or **zooids**. Zooids are mainly **Polyps** (sessile and asexual zooid) and **Medusae** (free swimming and sexual zooid).
9. Usually **carnivorous,** digestion **extracellular** as well as **intracellular**. Anus is absent.
10. Respiratory, circulatory and excretory systems are absent.
11. Reproduction takes place by both ways **asexual** (budding) and **sexual** (by formation of gametes).
12. **Planula** larva is present in the life cycle. **Alternation of generation (metagenesis)** takes place in which asexual polypoid generation alternates with sexual medusoid generation.

Classification

PHYLUM-COELENTRATA

Class

1.HYDROZOA 2. SCYPHOZOA 3. ACTINOZOA (ANTHOZOA)

- Polypoid generation or medusoid generation or both.
- Solitary or colonial.

- Exclusively medusoid, polyps absent.
- Umbrella shaped medusae without velum.

- Exclusively polypoid, medusae absent.
- Gastrovascular cavity divided by 8 or more mesenteries.

Order1:**Hydroidea**

- Polypoid stage is predominant.
- Medusae present or absent.

Examples: *Hydra, Obelia.*

Order2: **Hydrocorallina**

- Calcareous exoskeleton.
- Polyps are dimorphic i.e. gastrozooids and dactylozooids.

Examples: *Millepora, Stylaster.*

Order 3: **Trachylina**

- Dominant medusoid stage, polyps poorly developed or absent.
- Sense organs are statocysts or tentaculocysts.

Examples: *Gonionemus, Cunia.*

Order 4: **Siphonophora**

- Exhibit Polymorphism.
- Polyps without tentacles and incomplete medusae which are rarely freed.

Examples: *Physalia, Porpita.*

Class2: Scyphozoa

Order1: **Stauromedusae**

- Globet, bell or trumpet shaped body.
- Sessile, sedentary attached by an aboral stalk.
- Tentaculocysts- absent.

Examples: *Haliclystus, Lucernaria.*

Order2: **Cubomedusae**

- Body cuboidal with four flat sides.
- Found in warm and shallow waters of tropical and subtropical regions.
- Tentaculocysts- 4.

Examples: *Charybdaea, Tamoya.*

Order 3: **Coronatae**

- Free swimming, inhabiting deep waters of ocean.
- Conical, dome shaped body.
- Tentaculocysts- 4-16.

Examples: *Pericolpa, Periphylla.*

Order 4: **Semaeostomae**

- The umbrella is flat, saucer or bowl shaped.
- Mouth is square
- Tentaculocysts- 8.

Examples: *Aurelia, Cynaea.*

Order 5: **Rhizostomae**

- Found in tropical and subtropical oceans.
- Saucer or bowl shaped.
- Tentaculocysts- 8 or more.

Examples: *Rhizostoma, Cassiopeia.*

Class3: Actinozoa (Anthozoa)

- They are exclusively polypoid, medusoid stage absent.
- Gastrovascular cavity is divided by 8 or more mesenteries.

Sub-class A. Octocorallia

- Colonial marine forms.
- Polyps always bear 8 pinnate hollow tentacles.

Order1: **Stolonifera**

- Polyps arise singly from a creeping base or stolon.
- Skeleton consist of loose spicules or of compact tubes and platforms.

Examples: *Tubipora, Clavularia.*

Order2: **Telestacea**

- Lateral polyps on single or branched stems.
- Skeleton of calcareous spicules.

Examples: *Telesto.*

Order 3: **Alcyonacea**

- Colony mushroom shaped or branched into stout blunt processes.
- Lower part of the polyp fused into a fleshy mass only oral ends protrude out (soft corals).

  Examples: *Alcyonium, Xenia.*

Order 4: **Coenothecalia**

- Skeleton is massive consisting of calcium carbonate.
- Commonly known as blue corals found in the Indo-Pacific coral reef.

  Examples: *Heliopora.*

Order 5: **Gorgonacea**

- Tree or feather like branched colony containing short polyps.
- Axial skeleton consisting of calcareous spicules or horn like material called gorgonin.

  Examples: *Gorgonia, Corallium.*

Order 6: **Pennatulacea**

- Elongated colony divided into proximal stalk and distal rachis (feather like).
- Main stem is supported by calcareous or horny skeleton

  Examples: *Pennatula, Renilla.*

Sub-class B. Hexacorallia

- Tentacles and mesenteries are six or multiples of six.
- Polyps are usually monomorphic.

Order1: **Actiniaria**

- Muscular body, cylindrical without skeleton.
- Pedal disc present on aboral end.

  Examples: *Metridium, Adamsia, Actinia*

Order2: **Zoanthidia**

- Solitary or colonial.
- Skeleton and pedal disc are absent but some calcareous bodies are present within the body wall.

Examples: *Zoanthus*, *Epizoanthus.*

Order 3: **Ceriantharia**

- Without pedal disc.
- Numerous mesenteries.

Examples: *Cerianthus.*

Order 4: **Madreporaria**

- Solitary or colonial hard corals.
- Hard calcareous skeleton is present.

Examples: *Madrepora*, *Favia.*

3.3.1 General Characters:-

1. *Obelia* is commonly called as **sea-fur**. It is sedentary marine colonial form attached on the surface of sea weeds, molluscan shells, rocks and wooden piles in shallow waters. It is widely distributed throughout the world.
2. It is a **trimorphic** colony present in the form of filamentous sea weed measuring several centimeters in height.
3. The basal horizontal portion is known as **hydrorhiza or stolon**. It helps in attachment with the substratum. It gives up vertical branches called hydrocaulus.
4. Hydrorhiza and hydrocaulus are covered by **chitinous perisarc** which encloses soft inner coenosarc.
5. **Coenosarc** is the living, hollow cellular tube made up of ectoderm, endoderm and mesoglea.
6. The trimorphic colony of *Obelia* posses three types of zooids **polyp** (hydranths), g**onangium** (blastostyle) and **medusa** (sexual zooid).
7. Polyp is the **nutritive zooid**. It is a bell shaped cup made up of lower **hydrotheca** and upper **hypostome**. Hypostome carries a ciclet of numerous **tentacles** provided with **nematocysts**.
8. **Blastostyle** is the club shaped **reproductive zooid** enclosed within a covering called **gonotheca**. It gives rise to buds which develop into medusa.

9. **Medusa** is the free swimming reproductive zooid consisting of upper exumbrellar (convex) and lowers sub-umbrellar (concave) sides. It is provided with marginal tentacles, four radial canals bearing gonads, a ring canal and a central hanging **manubrium** on the concave side.
10. It reproduces by asexual as well as sexual methods. Life history of *Obelia* exhibits **alternation of generation**.

3.3.2 - Identifying character:-

Alternate branches of polyps and blastostyles.

3.3.3- Systematic Position:-

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Hydrozoa (Hydroids, medusa with velum)

Order ……………...Hydroidea (Polypoid generation well developed)

Genus ……………..*Obelia*

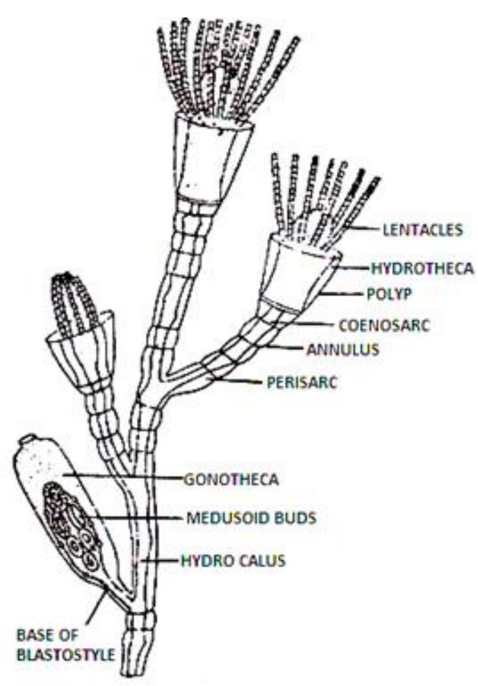

Fig 3.1: Obelia Colony

3.4– Physalia:-

3.4.1General Characters

1. *Physalia* is a colonial hydroid commonly called **Portuguese man of war**. It is a marine, colonial, swimming or floating pelagic animal. Distributed in tropical and subtropical seas.
2. Colony consists of large gas filled **pneumatophore** or float which is bright blue in colour. It floats above the surface.
3. Pneumatophore contains **gas glands**. It produce a gas having 90% nitrogen, 9% oxygen and 1% argon while swimming the pneumatophore is filled with gas and when animal has to sink the gas is released out.
4. Beneath the float three main types of zooids hang down
   (i) **Gastrozooids** – Nutritive zooids having mouth but tentacles are absent.
   (ii) **Dactylozooids** – these help to caphere the prey for food. They have numerous nematocyst bearing tentacles.
   (iii) **Gonozooids** – Reproductive zooids bearing clusters of male and female medusa.
5. Tentacles are large and bear **stinging batteries** or **nematocysts** to kill fishes.

3.4.2 Identifying Character:-

Pneumatophore (float), hanging gastrzooids, tentacles and gonozooids.

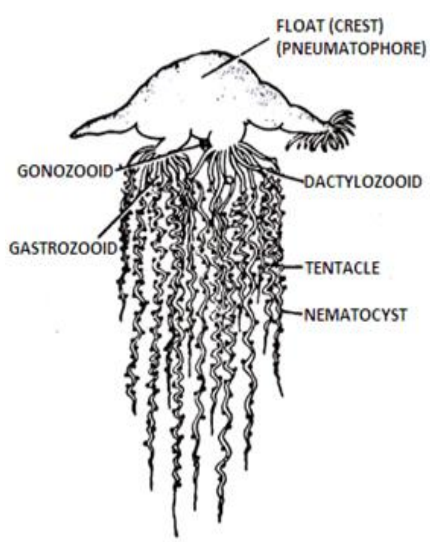

Fig 3.2: Physalia

3.4.3-Systematic Position

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Hydrozoa (Hydroids, medusa with velum)

Order ……………...Siphonophora (Polymorphic colonies, numerous polypoid and medusoid zooids)

Genus ……………..*Physalia* (The Portuguese man -of -war)

3.5 *Porpita*

3.5.1General Characters

1. *Porpita* is a colonial marine hydroid found in tropical and sub-tropical water of the Pacific, Atlantic and Indian oceans.
2. It is commonly known as **blue button**.
3. The colony is **disc shaped** resembling to medusa.
4. Body is disc like with a **chitinous**, chambered **pneumatphore** containing air. It opens to exterior by pores.
5. A large central **gastrozooid** bearing mount leading to wide gastric cavity is present on the ventral side.
6. Numerous **gonozooids** bearing medusa encircle the gastrozooid.
7. Numerous long dactylozooids bearing nematocysts are present on the margin of disc.
8. The reproductive zooids are liberated as free **medusa**.

3.5.2- Identifying character:

Presence of central disc surrounded by tentacles.

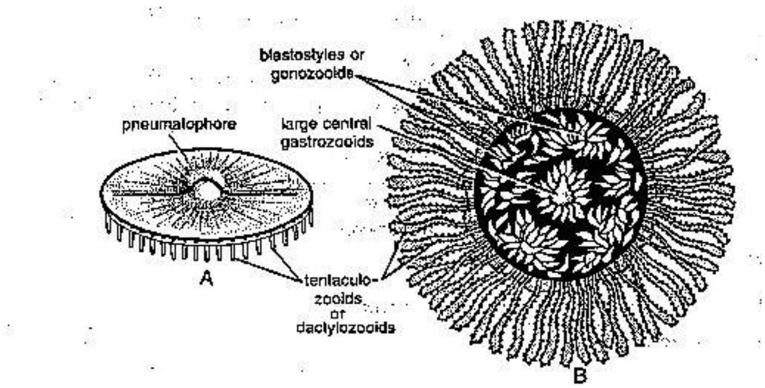

Fig.3.3: Porpita A Dorsal view B Oral ventral side

3.5.3 Systematic position:-

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Hydrozoa (Hydroids, medusa with velum)

Order ……………...Siphonophora (Polymorphic colonies, numerous polypoid and medusoid zooids)

Genus ……………..*Porpita*

3.6 Vellela

3.6.1General Characters:-

1. *Vellela* is commonly called **little sail**. It is most beautiful open sea form consisting of deep blue colony.
2. It is commonly distributed in warm seas.
3. The float or **pneumatophore** is a chambered disc containing air in the chambers and having **vertical sail** on the top.
4. Large single **gastrozooid** hangs in the centre. At ventral side it bears mouth.
5. Numerous medusa bearing **gonozooids** are present around the gastrozooid.
6. Tentacle like **dactytozooids** bearing nematocysts is present on the margin of disc.
7. Gonozooids produce free **medusa.**
8. It exhibits the phenomenon of **polymorphism**.

3.6.2- Identifying character:

Presence of sail and single gastrozooid

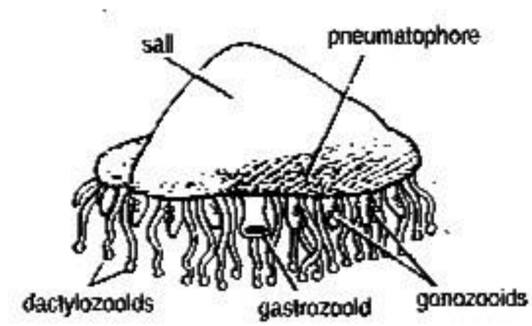

Fig 3.4: Velella

3.6.3 Systematic Position:-

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Hydrozoa (Hydroids, medusa with velum)

Order ……………...Siphonophora (Polymorphic colonies, numerous polypoid and medusoid zooids)

Genus ……………..*Velella* (Little sail)

3.7- *Tubipora*

3.7.1 General characters

1. *Tubipora* is commonly called **organ pipe coral**. It is highly calcified coral.
2. It is a marine colonial **plypoid anthozoa** distributed in warm waters of Atlantic, Indian and Pacific Oceans.
3. The colony consists of long parallel upright polyps enclosed in vertical skeleton tubes arising from **basal plates**.
4. Polyps are united by horizontal platforms at definite intervals formed by fusion of **spicules.**
5. Mesogleal spicules become closely fitted to form a continous tube for each polyps.

6. Skeleton is internal and covered by **ectoderm** in living condition.
7. The polyps are green in colour but skeleton becomes dull red due to the presence of **iron salts.**
8. Reproduction take place **asexually** by budding..

3.7.2- Identifying Character:

Compact red coloured vertical tubes.

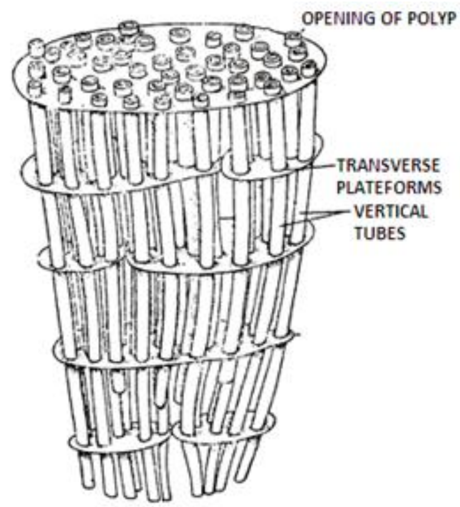

Fig. 3.5: Tubipora A Portion of living colony B Portion of dead coral

3.7.3: Systematic Position

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Anthozoa (Only polypoid generation, sedentary, solitary or colonial)

Order ……………...Stolonifera (Polyps not fused but communicate with each other through basal plate)

Genus ……………..*Tubipora* (Organ pipe coral)

3.8 Millepora:-

3.8.1-General Characters:-

1. It is commonly known as **stinging coral** as its powerful nematocysts are painful to man.
2. It is a **colonial** marine coral distributed throughout the tropical shallow waters of West Indies and U.S.A.
3. Colony consists of upright leaf like calcareous growth, white or yellowish in colours.

4. The surface of colony bears pores of 2 sizes the larger **gastropores** and smaller **dactylopores.**
5. Colony has two types of zooids i.e. **gastrozooids** – shorter having mouth and tentacles and **dactylozooids** – long, slender, hollow tentacles without mouth.
6. Medusae originate from **coenosarcs**. They don't have mouth and tentacles and are short lived.
7. Dried colonies form irregular mass.

3.8.2-Identifying Character:

Presence of gastropores and dactylopores

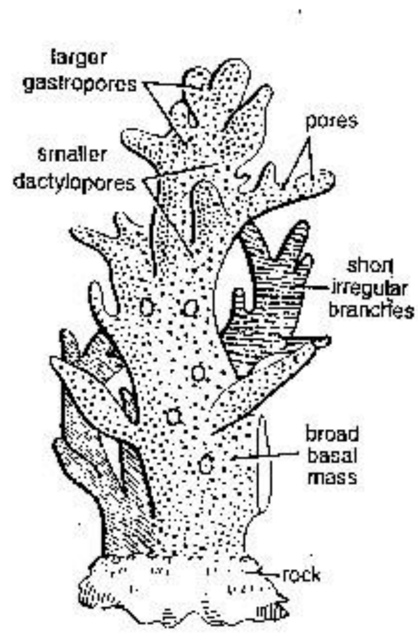

Fig 3.6: Millepora

3.8.3-Systematic position:-

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Hydrozoa (Hydroids, medusa with velum)

Order ……………...Hydrocorallina (Coenosarc secretes exoskeleton, dimorphic polyps)

Genus ……………..*Millipora*

3.9 – *Aurelia*

3.9.1 – General Characters:-

1. *Aurelia* is commonly known as **Jelly-fish**. It is a solitary, marine, medusoid form inhabiting warm and temperate seas throughout the world.
2. Body is transparent, bluish white in colour. Inner organs are visible from body surface.
3. Circular body measuring about 90 mm in diameter having convex **aboral** (exumbrellar) and concave **oral** (sub umbrella) surface.
4. Four red or purple **horse-shoe shaped gonads** are visible from aboral surface.
5. Mouth is four cornered each corner continues into four long and narrow oral lobes hanging down from oral surface.
6. Subumbrellar margin contain marginal tentacles having **stinging cells** and 8 marginal **lappets** having sense organs called **tentaculocysts (rhopalium).**
7. Jelly fish is **carnivorous** feeding on small animals like molluscs, crustaceans, protozoans, nematodes etc.

3.9.2 Identifying Character:

Jelly like texture, marginal tentacles and oral arms

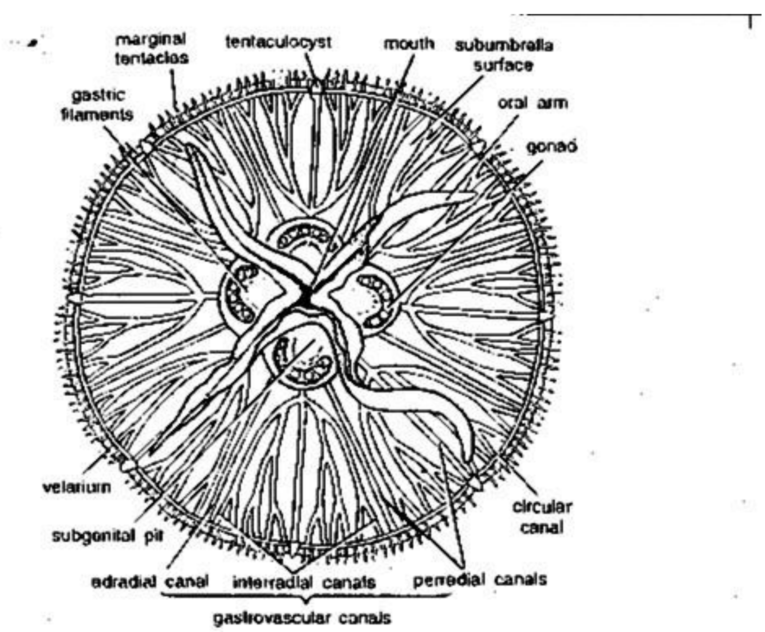

Fig. 3.7: Aurelia oral view

3.9.3- Systematic Position

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Scyphozoa (Medusa well developed, hydroid reduced)

Order ……………...Semaeostomeae (Free swimming scyphomedusae with umbrella like disc and oral lobes)

Genus ……………..*Aurelia* (Jelly fish)

3.9.4 – Larval stages of Aurelia:

Life cycle of Aurelia includes 3 larval stages as follows –

(A) Planula Larva:

Comments:

(i) Fertilized egg undergoes cleavage to form morula and gastrula which further give rise to ciliated larva called **planula larva**.

(ii) It becomes elongated and **ciliated**.

(iii) Planula larva consists of ciliated **ectoderm, mesoglea, endoderm** and **coelenteron**.

(iv) Fully developed planula larva is present on the frills of oral arms of *Aurelia*.

(v) Planula larva escapes and gives rise to next larval stage called **scyphistoma larva**.

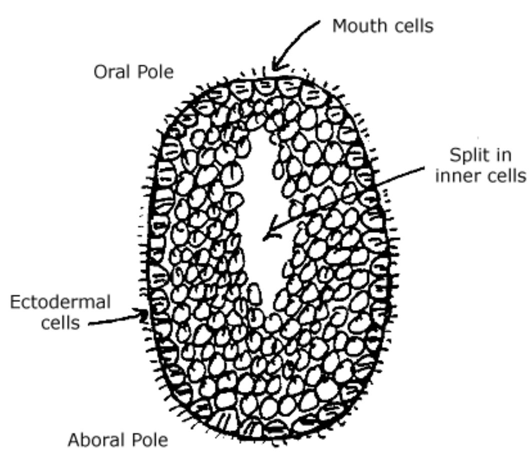

Fig. 3.8. (A) Planula larva

(B) Scyphistoma Larva:

Comments:

(i) The planula larva swims for some time and attaches to a substratum by **aboral** end.

(ii) Cilia are lost and a **mouth** opens at its free distal end.

(iii) The larva is metamorphosed into about 5 mm high, small trumpet-shaped or hydra like polyp.

(iv) It consists of an adhesive **basal disc** containing stalk like organ having oral end containing **mouth, manubrium** and **tentacles**.

(v) The number of tentacles vary from 16 to 32. These are named as **Perradia** (1^{st} four), **interradial** (next four tentacles) and remaining are **adradial** tentacles.

(vi) In autumn and winter scyphistoma undergoes process of budding or transverse fission at oral ends known as **strobilization**.

(vii) During strobilization the scyphistoma with segmented body break at intervals each segment forms an **ephyra larva**.

(viii) During the favourable conditions several ephyrae are produced at one time (**polydisc strobilization**). During unfavorable conditions single ephyra is produced at a time **(monodisc strobilization).**

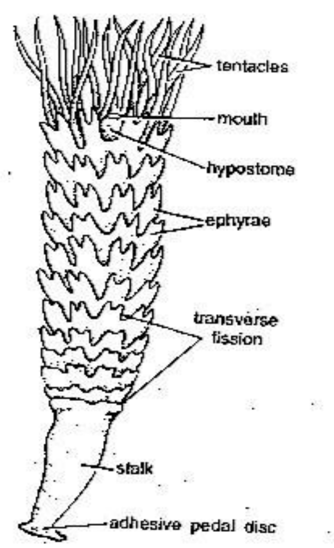

Fig. 3.8. (B): Scyphistoma Larva

(C) Ephyra Larva

Comments:

(i) Scyphistoma larva gives rise to Ephyra larva.

(ii) It is small medusoid from.

(iii) Saucer-shaped or umbrella like body having tetramerous symmetry.

(iv) 8-long forked arms having marginal lappets are present.

(v) 8-prominent tentaculocysts are present in the notches between marginal lappets.

(vi) Manubrium with the mouth is present in the middle on ventral surface.

(vii) Ephyra larva swims actively in the water and metamorphoses into adult Aurelia.

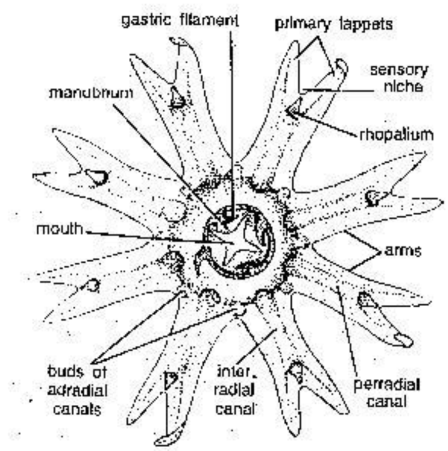

Fig 3.8(C): Ephyra Larva

3.10 – *Gornonia*

3.10.1 General Characters:-

1. *Gorgonia* is commonly known as **sea fan.** It inhabits shallow tropical seas near Malaya, West Indies and Indo-Pacific Ocean.
2. It forms **branching colonies** of yellow and red colour growing up to 50 cm in height.
3. Body consists of plant-like branching stems and a short main trunk attached to the substratum by a **pedal disc**.
4. Numerous small **anthocodia (retractile polyps)** are present in rows on either side of stems of branches.

5. Skeleton consists of an **axial rod** present throughout the body. It is made up of **gorgonin** (flexible horn like ectodermal material).
6. It contains numerous **spicules** in the mesoglea.
7. Sexes are separate.

3.10.2 Identifying Character:

Fan shaped body.

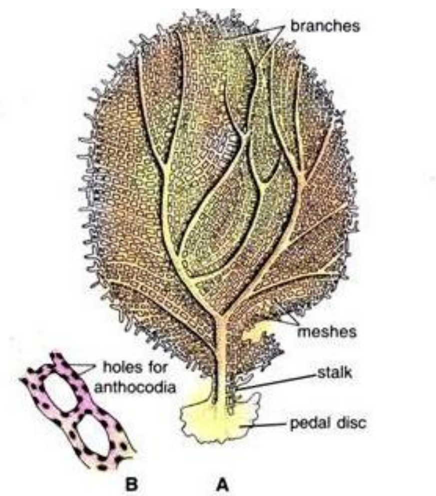

Fig 3.8 – Gornonia A- Complete specimen B- A magnified portion

3.10.3 Systematic Position:-

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Anthozoa (Only polypoid generation, sedentary, solitary or colonial)

Order ……………...Gorgonacea (Horny corals, short polyps not touching base)

Genus ……………..*Gorgonia* (Sea fan)

3.11 – *Alcyonium:-*

3.11.1 General Character:-

1. *Alcyonium* is commonly known as dead men's finger or soft coral. It is found attached to rocks and stones in Indo-Pacific Ocean.
2. Colony conists of a **stalk** and thick soft **leathering lobes**.
3. The promixal part i.e. stalk is devoid of zooids and the distal lobes posses zooids.

4. Fleshy mass called **Coenonchyma** is present above stalk from which polyps project out.
5. Each polyp contains 8-**pinnate tentacles**.
6. **Spicules** are found throughout the mesoglea which give support to coenonchyme.
7. **Gonads** develop during breeding season on the mesenteries of polyps. Fertilization is external.
8. Life cycle includes free swimming **Planula larva** which fixes itself to substratum and give rise to a new colony by budding.

3.11.2 Identifying Character:

Presence of star shaped polyps and finger like soft body.

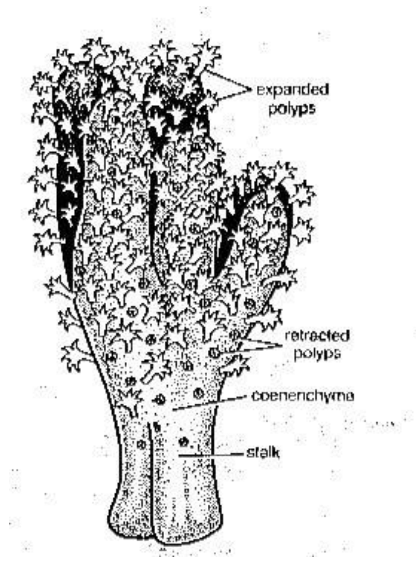

Fig 3.9: *Alcyonium*

3.11.3 Systematic Position:-

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Anthozoa (Only polypoid generation, sedentary, solitary or colonial)

Order ……………...Alcyonacea (Basal plate forms fleshy mass)

Genus ……………..*Alcyonium* (Dead man's finger)

3.12 Adamsia:-

3.12.1 – General Character:-

1. *Adamsia* is found attached on the empty gastropod shells inhabited by hermit crab (*Euparagus*). It is distributed in shallow water of U.S.A. and Indian Ocean.
2. Body is large, cylindrical and divided into three parts – pedal disc, coloumn and oral disc.
3. **Pedal** is flat, sucker like and bilobed. It helps in attachment to molluscan shell.
4. **Coloumn** is cylindrical bearing a band of cinclidal tubercles at its base.
5. **Oral disc** bears a central mouth encircled by numerous (500 approx) nematocyst bearing tentacles.
6. *Adamsia* shows a good example of commonsalism (mutual benefit). *Adamsia* is carried to different places **hermit crab** living inside empty mollusc shell and gets variety of food. Hermit crab gets protection inside the shell as well as *Adamsia* covers its body and protects the crab from attacks of enemies by stinging with **nematocysts.**

3.12.2 – Identifying Character:

Adamsia living in commensalism on a **molluscan shell** inhabited by **hermit crab** (*Euparagus*)

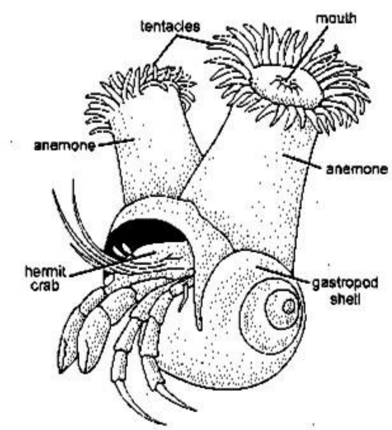

Fig 3.12 – Adamsia

3.12.3 – Systematic Position:

Phylum …………...Coelentrata (Tissue grade organization, diploplastic and acoelomate)
Class ……………....Anthozoa (Only polypoid generation, sedentary, solitary or colonial)
Order ……………...Actiniaria (Skeleton absent, mesenteries of septa in multiple of six)
Genus …………….*Adamsia*

3.13– Hydra

3.13.1 General Characters:-

1. *Hydra* is a solitary, freshwater and **cosmopolitan** hydrozoan found attached to some objects in lakes, ponds and streams all over the world but most common in India, Canada and U.S.A.
2. It is a **polypoid**, tubular and cylindrical coelenterate and measures about 1 cm when fully extended.
3. Proximal end is called **basal disc** and contains gland cells which secrete adhesive secretion for attachment.
4. The free distal or oral end bears mouth situated on a conical projection called **hypostome**.
5. Hypostome is encircled by 6-10 hollow, slender tentacles provided with **nematocysts.**
6. Body wall is **diploblastic** consisting of an outer **ectoderm** and inner **endoderm** separated by **mesoglea.**
7. Mouth leads to **gastrovascular** cavity.
8. Lateral buds may be present on the sides of the body which give rise to new individuals by **budding**.
9. **Gonads** are present as buds on the body. **Testes** are situated near the oral and end while **ovaries** near the base.
10. Reproduction by both **asexual** (budding) and **sexual** methods. *Hydra* posses great power of **regeneration**. Thus extensively used for experimental studies on regeneration.
11. *Hydra viridis* contains symbiotic green alga *Zoochlorellae.*

3.13.2 Identifying Character: -

Raised hypostome and polypoid body:

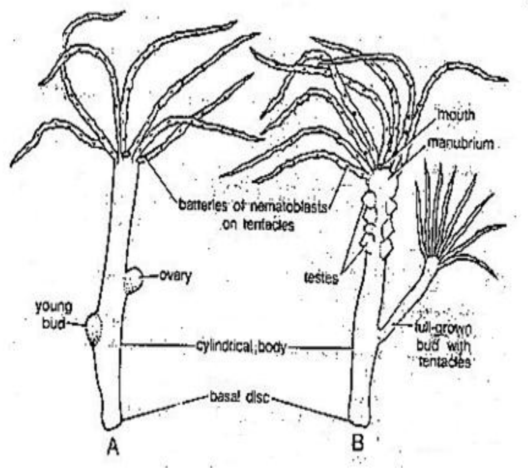

Fig: 3.13 Hydra A Female B Male

3.13.3 Systematic Position:-

Phylum ……………Coelentrata (Tissue grade organization, diploplastic and acoelomate)

Class ……………....Hydrozoa (Hydroids, medusa with velum)

Order ……………...Hydroidea (Polypoid generation well developed)

Genus ……………..*Hydra*

3.17 – References:-

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UNIT 4: PHYLUM: PLATYHELMINTHES (Flatworms)

General characteristics:-

1. Platyhelminths are bilaterally symmetrical and dorso-ventrally flattened.
2. Body wall is triploblastic (form 3 germ layers- epidermis, mesodermis and endodermis).) Below the endodermis longitudinal. Circular and oblique muscles are present.
3. Acoelomate (true coelom is absent) and unsegmented except class Cestoda.
4. They are free living, parasitic or commensals.
5. Adhesive organs like hooks, suckers and spines are present with adhesive secretions.
6. They show a blind sac body plan i.e. mesodermal tissue called mesenchyme/parenchyma is present between the internal organs and all these are filled in a sac like body having no other opening.
7. Digestive system is absent in Cestoda and Acoela but in others consist of mouth, pharynx and blind intestine without anus.
8. Respiration and circulatory system are absent.

9. Excretory system consists of single or paired protonephridia with flame cells or bulb except Acoela.
10. Nervous system is primitive, ladder like. It contains a pair of cerebral ganglia with longitudinal nerve cords connected by transverse nerves.
11. Sense organs are commonly present in Turbellarians but greatly reduced in parasitic form.
12. Generally they are hermaphrodite with few exceptions.
13. Reproductive system is highly evolved and complex. Sexual and Asexual reproduction both are present. Fertilization internal.
14. One or more hosts are required to complete their life cycle and larval forms usually present.

Outline classification:

Phylum Platyhelminthes

Classes

Turbellaria

- They are mostly free living but some are commensals or parasitic
- Life-cycle simple

Trematoda

- Endo/ecto pasitic, Commonly called as flukes
- Life- cycle simple/ complicated

Cestoda

- Endoparasitic in the intestine of vertebrte
- Life cycle complicated with hooked embry & usually involves to or most host

Sub-class

Cestodaria

-Body is undivided
-Larva with 10 hooks
-Only single set of reproductive organs

Eucestoda

- Body is divided into fewto many segments rarely undivided
- -Larva with 6 hooks
- More than one set of reproductive organs present in each segment

1. **Class: Turbellaria**

Order-Acoela

- Exclusively marine.
- Oviducts and yolk glands absent.
- Ex. *Convoluta*,*Ectocotyle*

Order- Rhabdocoela

- Freshwater, marine and terrestrial form.
- Few compact gonads & oviducts present.
- Ex. *Monodiscus*

Order- Alloecoela

- Mostly marine.
- Small numerous testes and a pair of ovaries present.
- Ex.*Otoplana*

Order- Tricladida

- Freshwater, marine and terrestrial form.
- Two to numerous testes and a pair of ovaries with yolk glands.
- Ex. *Planaria*

Order- Polycladida

- Exclusively marine.
- Testes and ovaries are numerous and sscattered.
- Ex. *Notoplana*

2. **Class: Trematoda**

Order-Monogenea

- Ecto or endo parasite or commensals.
- Only single host in life cycle.
- Ex. *Polystoma*

Order-Digenea

- Mostly endoparasites in vertebrates and invertebrates.
- Two or three intermediate host is present.
- Ex. *Fasciola hepatica* (Liver fluke), *Schistosoma* (Blood fluke).

Order-Aspidobothria

- Endoparasite in the gut of fishes and reptiles.
- No alteration of host.
- Ex. *Aspidogaster*

3. Class: Cestoda

(A) **Sub-class:Cestodaria(**Monozoic, no scolex and strobilia

Order-Amphilinidia

- Suckers are absent.
- Endo-parasite (occur in intestine of fishes).
- Ex. *Amphilina*

Order- Gyrocotylidea

- Sucker present (only anterior).
- Endoparasite of fishes.
- Ex. *Gyrocotyle*

(B) **Sub-class: Eucestoda** (Polyzoic, Scolex, neck and Strobilia present)

Order- Tetraphyllidea

- Endoparasite in intestine of elasmobranch fishes.
- Scolex with 4 leaf like suckers.
- Ex. *Phyllobothrium*

Order-Pseudophyllidea

- Found in the intestine of vertebrates.
- Scolex has 2 to 6 suckers.
- Ex. *Bothriocephalus*

Order-Diphyllidea

- Endoparasite in the intestine of elasmobranch fishes.
- Scolex contains two suckers and stalk with spiny head.
- Ex. *Echinobothrium*

Order- Trypanorhyncha

- Found in spiral valve of alimentary tract of elasmobranchs.
- Four suckers and four protrusible spiny proboscides present in scolex.
- Ex. *Tetrarhynchus*

Order-Taenioidea

- They are endoparasite, found in intestine of birds and mammals.
- Scolex has four suckers.
- Ex. *Taenia solium*

4.1 *Dugesia (=Planaria; Euplanaria)*

4.1.1 General characters:

1. Planaria (Dugesia) is found in freshwater streams, springs, ponds, lakes and shallow rivers of cold running water (See fig. no. 4.1).
2. They are found in India , Myanmar, U.K ,U.S,A and U.S.S.R

3. Body elongated leaf like, bilaterally symmetrical, with a broader anterior end and pointed posterior end & dorsoventrally flattened.
4. They are brown or black in color with size vary from 2 to 15 mm.
5. Head is broad, blunt, and triangular with laterally on either side auricles and two eyes.
6. Digestive system comprises of mouth (on ventral surface), everted pharynx (proboscis) and branched intestine.
7. Proboscis is covered with the proboscis sheath.
8. Intestine forks into three diverticulated branches, one anterior and two posterior.
9. Genital pore is situated a little posterior to the mouth.
10. Reproduction is sexual and asexual.
11. Planarians are used in experiment for regeneration and grafting.

4.1.2 Identifying characters:

Presence of auricles, a pair of simple eyes.

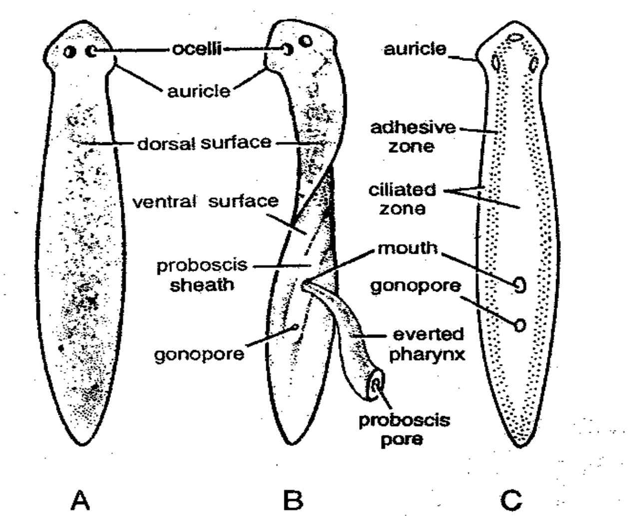


Fig. 4.1 *(A) Dorsal surface; (B) Body twisted to show a part of ventral surface; (C) Ventral surface*

4.1.3 Systematic position:

Phylum---- Platyhelminthes - Flatworms, acoelomate

Class---- Turbellaria - Ciliated epidermis, adhesive organs present

Order---- Tricladida - Gonopore single, pharynx protrusible, intestine with three branches

Genus--- *Dugesia (Euplanaria)*

Species--- *tigrina*

4.2 Liver fluke *Fasciola hepatica*:-

(a) ***Fasciola hepatica*:**(Liver fluke)

4.2.1General characters:

1. *Fasciola hepatica* is found in the bile duct of liver of sheep as endo parasite (See fig. no. 4.2).
2. Body is leaf –like, dorso – ventrally flattened measures 25-30 mm in length and 4-5 mm in breadth.
3. Anterior end is produced into a conical projection is known as cephalic cone.
4. Posterior end is large more rounded in front than behind.
5. Mouth is situated ventrally at anterior end and surrounded by oral sucker.
6. Digestive system comprised of pharynx,oesophagus and diverticulated intestine.
7. They are Hermaphrodite.
8. Excretory pore is found at the posterior extremity.

4.2.2 Identifying characters:

It has cephalic cone, acetabulum, anterior end is broad and rounded while posterior end is bluntly pointed.

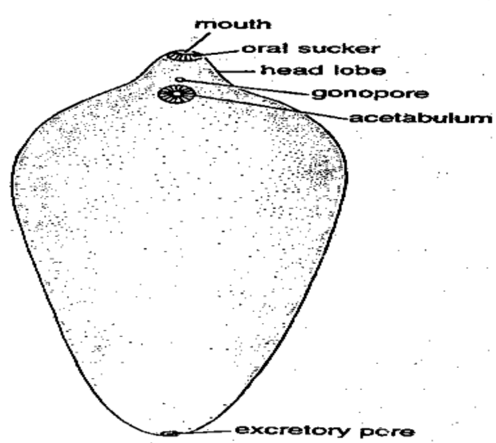


Fig. 4.2*Fasciola hepatica*

4.2.3 Systematic position

Phylum ---Platyhelminthes - Flatworms, acoelomate

Class ---- Trematoda - Body wall without opidermis and cilia, Parasitic nature suckers are well developed.

Order ----Digenea - Endoparasitic,many larval stages present,Two suckers without hooks

Genus ----*Fasciola*

Species--- *hepatica*

4.2.4 T.S of *Fasciola hepatica*

(i) T.S of *Fasciola hepatica* through Testes

Comments:

1. Section passes through the posterior three-fourth region (as shown in fig. no. 4.3).
2. Outermost covering of the body made up by cuticle. It forms numerous scales.
3. Musculature composed of outer circulars, middle longitudinal and inner oblique muscles.
4. Various stages of development of spermatozoa are seen in the transverse sections of testes .
5. The sections of vitelline ducts and vitelline glands are clearly visible on the lateral sides.
6. The space between body wall and internal organs (Mesenchyme) is filled with mesenchymal cells.
7. Coelom is totally absent.

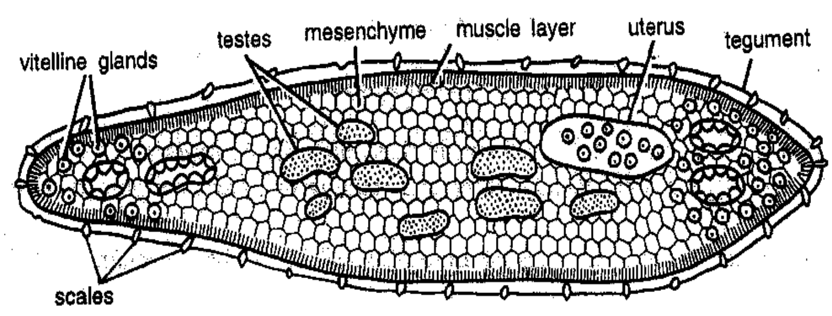


Fig. 4.3 T. S. of *Fasciola hepatica* through testes

(ii) T.S of *Fasciola hepatica* through Uterus:

Comments:

1. Epidermis is absent. Body wall consists of outer circular,longitudinal, and inner oblique. It is surrounded by cuticle (as shown in fig. no. 4.4).
2. Sections of uterus,ovary and few portion of gut are seen.
3. Fertilized eggs are seen in the section of uterus.
4. On the lateral side vitelline glands and vitelline ducts cut into small sections.
5. Coelom is absent.
6. The space between the body wall and the internal organs is filled with mesenchymal cells.

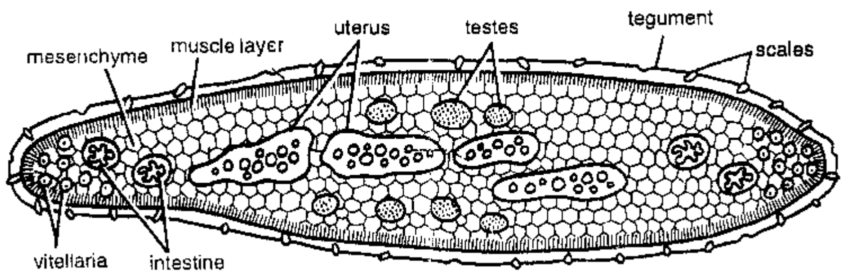


Fig. 4.4 T.S of *Fasciola hepatica* through Uterus

(iii)T.S of *Fasciola hepatica* through Posterior Sucker

Comments:

1. Body wall consists of cuticle and muscle layers. Epidermis is absent (as shown in fig. no. 4.5).
2. Cuticle is the outermost layer provided with numerous scales.
3. Musculature composed of outer circulars, middle longitudinal and inner oblique muscles.
4. Coelom absent.
5. The interior of the body is filled with parenchyma.
6. On lateral side vitelline glands and few intestinal caeca are present.
7. On ventral surface a large, muscular posterior sucker or acetabulum is seen.

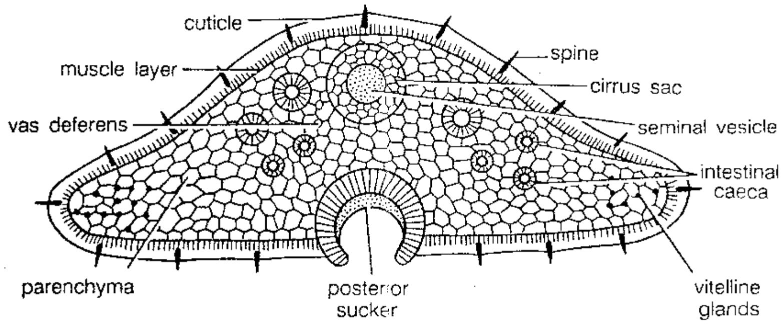


Fig. 4.5 T.S of *Fasciola hepatica* through Posterior Sucker

4.2.5 Developmentalstages of *Fasciola hepatica:-*

(i)Eggs of *Fasciola hepatica*

Comments

1. Fertilized Eggs are brown in color and oval in shape (as shown in fig. no. 4.6).
2. About 3000 or more such capsule may occur at a time in the uterus of a single fluke.
3. A Fertilized egg measured about 63to 90 microns in width and 130 to 150 microns in length.
4. The fertilized eggs received yolk cells from vitelline glands and they get enclosed in a chitinous shell (egg shell).
5. Each egg (hardens shell) has an operculum or lid.
6. Segmentation of complete eggs (capsule) starts in uterus.
7. First division is holoblastic & devides the zygote(Fertilized egg) into two unequal cells---
   (i) **Propogatory cells** (small):- Propagatory cell divided into two cells, one of which forms endoderm and mesoderm of the larva
   (ii) **Somatic cells** (larger) :- Somatic cell divides and forms ectoderm of the larva.
8. Fully embryonated egg has miracidium larva, few yolk cells and germ cells.

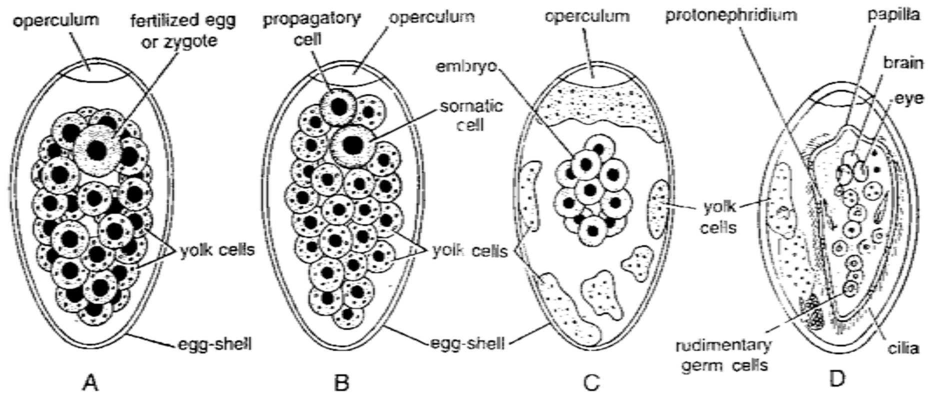


Fig. 4.6 *Early stages of development of Fasciola hepatica*

(A) Fertilizaed egg; (B) Two celled stage;

(B) Many celled stage; (D) Miracidium in capsule

(ii)Miracidium Larva of *Fasciola hepatica*

1. Fertilized eggs (Zygote)or encapsulated embryodevelops into Miracidium larva after 4-15 days (as shown in fig. no. 4.7).
2. Hatching is initiate by a proteolytic hatching enzyme.
3. It is free swimming, microscopic, dorso-ventrally flattened, conical in shape and covered with ciliated epidermal plates.
4. Epidermal plates (hexagonal) are taxonomic importance, which are 21 in number and arranged in 5 rows
   (i) First row has 6 plates (2 dorsal, 2 ventral and 2 lateral)
   (ii) Second row has 6 plates (3 dorsal and 3 ventral)
   (iii) Third row has 3 plates (1 dorsal & 2 ventro-lateral)
   (iv) Fourth row has 4 plates (2 right and 2 left)
   (v) Fifth row has 2 plates (1 left and 1 right)
5. Body wall contains ----
   (i) Muscle layer
   (ii) Glandular epithelium
   (iii) Delicate fluid-filled mesenchyme cells
   (iv)
6. Anterior end is produced into a conical papilla, which is mobile and non-ciliated.

7. Internal structures apical gland is non functional, cephalic or penetration glands secrete secretions, brain, two eye spots, two flame cells,rudimentary gut and germ cells are seen.
8. Miracidium is multicellular organism.
9. Miracidium larva swims in search of intermediate host (a molluscan), if it gets a suitable host it change into next larval stage (Sporocyst).
10. If Miracidium larva doesn't comes in contact with intermediate host thelarva dies after 24 hrs.

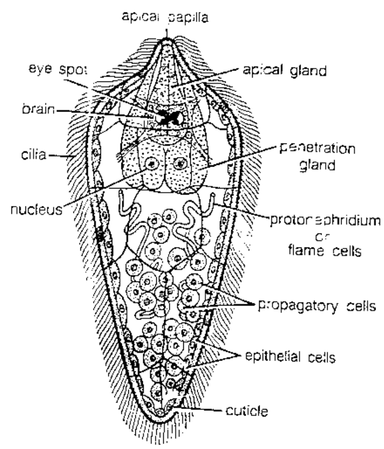


Fig. 4.7 *Miracidium Larva of Fasciola hepatica*

(iii)Sporocyst of *Fasciola hepatica*

1. Miracidium larva on getting a suitable snail penetrates into the body of snail and metamorphoses into intramollusca phase, called sporocyst larva (as shown in fig. no. 4.8).
2. This larva stage develops from Miracidium larva in the pulmonary chamber of snail.
3. It penetrates through pulmonary chamber and during this process cilia and hexagonal cells, brain eye spots apical &penetration gland are degenerated.
4. Sporocyst is an elongated sac- like structure covered with cuticle. Measuring about 1 mm in diameter.
5. Sporocyst is non-feeding stage.
6. Body wall consists of epithelial cells, muscles and mesenchyme.
7. Ciliated epidermis is absent which is lost in the process of penetration and it replaced by a thin cuticle.

8. Body sac has flame cells and germ cells.
9. Germ cells multiply and give rise to next larval stage known as redia larva. Each sporocyst produces 5-8 rediae.

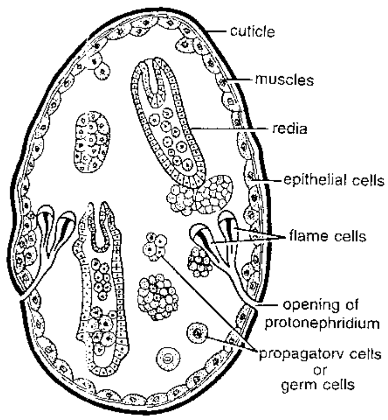


Fig. 4.8 Sporocyst of *Fasciola hepatica*

(iv)Redia Larva of *Fasciola hepatica*

1. Redia Larva develops when the germ cells of the sporocyst multiplies (as shown in fig. no. 4.9).
2. Each redia is an elongated and cylindrical structure about 1.3 mm to 1.6 mm long.
3. Anterior end bears the mouth, muscular swelling or collar (which helps in locomotion)

   anda permanent birth pore.
4. Two stumpy processes known as lappets or procruscula ventro-laterally at the posterior end which helpful in locomotion.
5. The space between the body wall and intestine contains few germ cells. It gives rise to second generation the daughter rediae.
6. Daughter redia and cercaria come out from mother redia through birth pore.

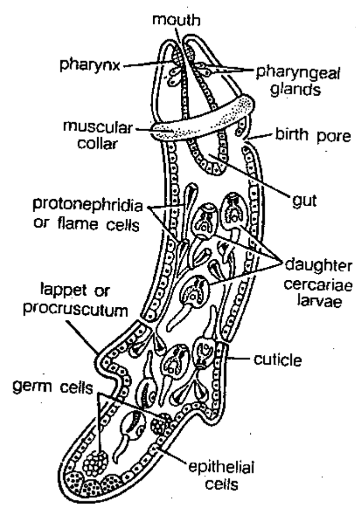


Fig 4.9 Redia Larva of *Fasciola hepatica*

(v) Cercaria Larva of *Fasciola hepatica*

1. Each redia produces 14 – 20 cercaria larvae (as shown in fig. no. 4.10).
2. After leaving the body of redia they enters in the digestive glands of snails.
3. Body of cercaria is flat and oval bearing a tail measuring 0.25 to 0.35mm in length and it is free swimming.
4. Body wall consists of cuticles, muscles and mesenchyme.
5. It has higher grade of organization and close resemblance with the adult fluke.
6. It has two suckers----

(i) anterior oral sucker surrounding the mouth and

(ii) ventral sucker situated in the middle of the body.

7. Body and tail are covered with backwardly directed spines.
8. Digestive system comprises mouth, oral sucker, muscular pharynx,oesophagus and inverted U shaped (forked) intestine.Acetabulum is present just below the forkofintestine.
9. Flames cells are present as exceratory organ and opens into a pair of excretory tubule which unite in front of tail to form an excretory vesicle or bladder.
10. Body space is filled with parenchyma and cystogenous glands on each side which form the cyst of thenext larva.
11. Rudimentary reproductive organs (Genital rudiments) are also present.

12. Cercaria larva has a very active life. After 2 or 3 days of active life its loses its tailand undergoes encystment to become metacercaria larva.
13. The encysted larva (Meta cercaria) is finally swallowed by sheep (final host).

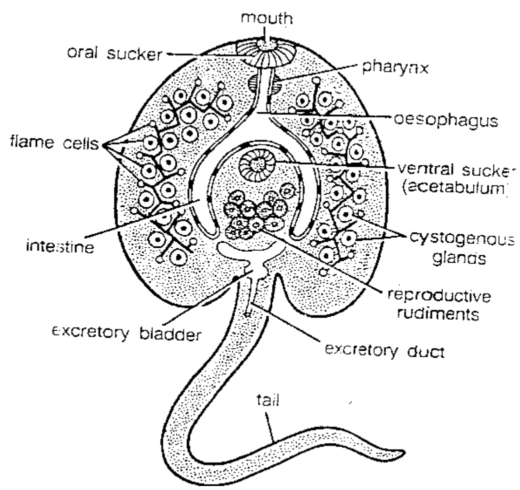


Fig. 4.10 Cercaria Larva of Fasciola hepatica

(VI) Metacercaria larva

1. They are round in shape with a diameter of 0.2 mm (as shown in fig. no. 4.11).
2. Metacercaria are basically juvenile fluke.
3. They are also called marita (Juvenile fluke).
4. Metacercaria has a round form,thick hard cyst and large number of flame cells.
5. They lacks a tail and cystogenous gland cells.
6. Its excretory bladder opens out directly through a single pore.
7. Cyst provides protection against short period of desiccation.
8. A single grass blade can have thousands of metacercria larva.

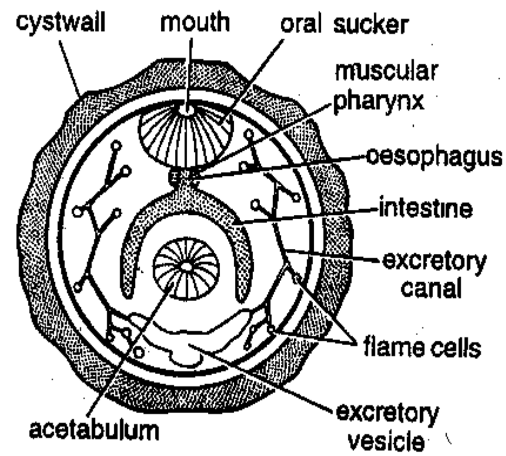


Fig. 4.11 *Metacercaria larva*

(b) ***Taenia solium***

4.2.1 General characters:

1. Commonly known as Tape Worm. Taenia solium is found in large intestine of man (see fig. no. 4.12).
2. Body comprises of scolex (head), neck and strobila (body).
3. Scolex is about 1 mm in diameter.In addition to suckers, scolex contain rostellum, which is pigmented and provided with a double row of hooks(number of hooks are about 28 to 32 in number).
4. Body comprises of large number of segments nearly 800 or more, these segments called proglottid.
5. Each segment(Proglottid) contain one set of male and female reproductive organs, part of execratory, nervous system and a lateral genital opening.
6. Life cycle involves two hosts

(i) Man-definitive host

(ii) Pig- intermediate host

7. When pigs eat contaminated human faeces becomes infected by bladder worm (Cysticercus larva).
8. Larva or bladder worm stage doesn't cause any damage to pig.
9. Human are infected by eating pork (pig meat) and *Taenia solium* develops into intestine of adult man.

4.2.2 Identifying characters:

Contains scolex, neck, great number of segments and all above characters, it is called *Taenia solium.*

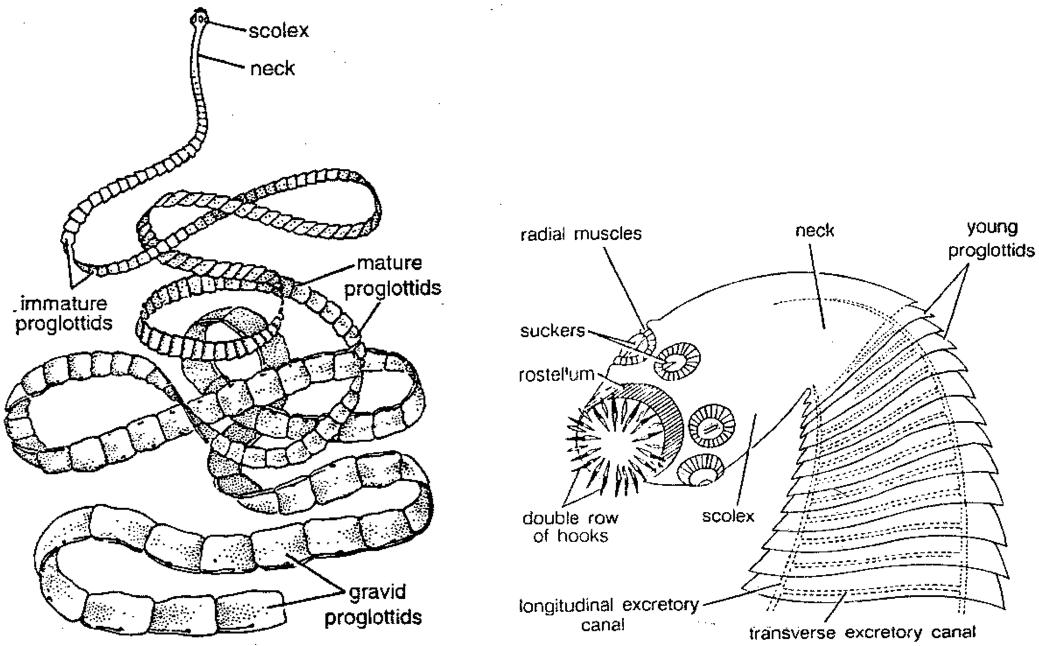


Fig. 4.12 (*A) Taenia solium* *(B) Scolex of Taenia solium*

4.2.3 Systematic position:

Phylum	Platyhelminthes	: Flatworms, acoelomate
Class -	Cestoda	:Endoparasitic, many segments (proglottids)
Subclass -	Eucestoda	: Ribbon like, anterior end with an expanded scolex having adhesive structure, each segment with more than one set of Reproductive organs.
Order -	Taenioidea	: Endoparasite , scolex with four suckers
Genus-	*Taenia*	
Species-	*solium*	

4.2.4(I) Mature Proglottid of *Taenia solium:-*

1. Each Mature Proglottid is square in shape.
2. Lateral side of each Proglottid contains lateral longitudinal nerve cords and lateral execretory canals.
3. A set of male and female reproductive organs is present in each mature Proglottid.
4. Male genital system consists of follicular testes, vasa efferentia, vas deferens and cirrus.
5. Female genital system consists of ovarian lobes (bilobed ovary), oviduct,ootype,vagina, uterus, Mehli's glands and compact vitellaria.
6. Oviducts divides into two ducts, one leading to vagina opening and other into uterus.
7. Vitelline gland lie behind ovary.
8. Male and female reproductive organs open into genital atrium.
9. The genital atrium opens by a common gonopore on a swollen genital papilla.

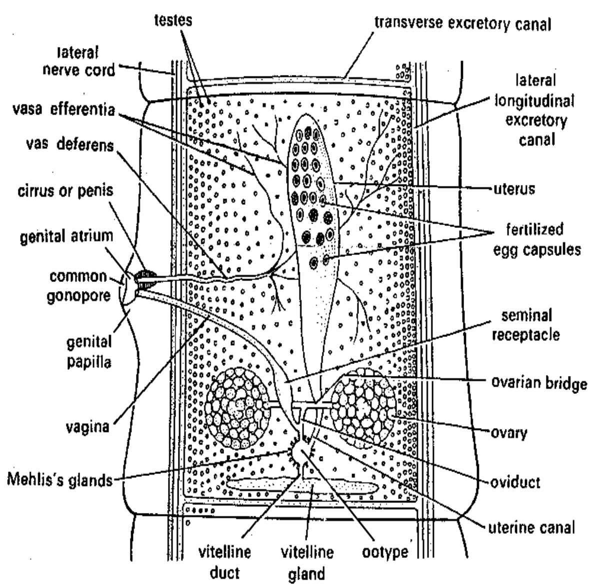


Fig. 4.13 *Mature Proglottid of Taenia solium*

4.2.4 (II) Gravid (ripe) proglottid of *Taenia solium:-*

1. The gravid are situated posteriorly (see fig. no. 4.14).
2. Each gravid proglottid is longer than broad and a highly branched uterus (7-13 lateral branches on each side) filled with fertilized eggs.

3. Other structure have disappeared in ripe proglottid.
4. Ripe proglottids are detachment from strobila by the process of apolysis and pass out from the intestine of host with faeces.
5. Sometimes, the gravid segment burst in the intestine and liberate several onchophores, show wriggling movement.

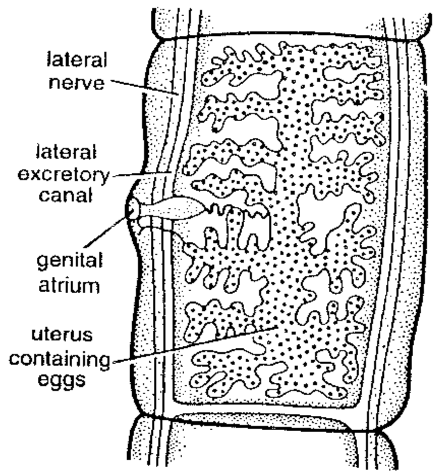


Fig 4.14 *Gravid (ripe) proglottid of Taenia solium*

4.2.5 Developmentalstages of *Taenia solium*

Cysticercus Larva of *Taenia solium*

1. Cysticercus larva is commonly called as bladder worm and develops in the muscles of pig(Intermediate host) (see fig. no. 4.15).
2. The onchospheres reaches pig stomach through human faeces.
3. The onchosphores further migrates to the muscles where hook are lost and the cells in the center of the embryo disappears and thus producing a single layered large ovoid bladder known as bladder worm or cysticercus.
4. Encysted larva consists of a sac or bladder like structure having proscolex , contains suckers and hooks .
5. Cysticercus larvae can be obtained after removing the cyst wall. If the larvae can be kept in normal saline solution the scolex is evaginated in 5 to 10 minutes.
6. Cysticercus consists of a sac or bladder –like structure, having invaginated proscolex measuring 6-18 mm in length.

7. The further development occurs when it is eaten by man.

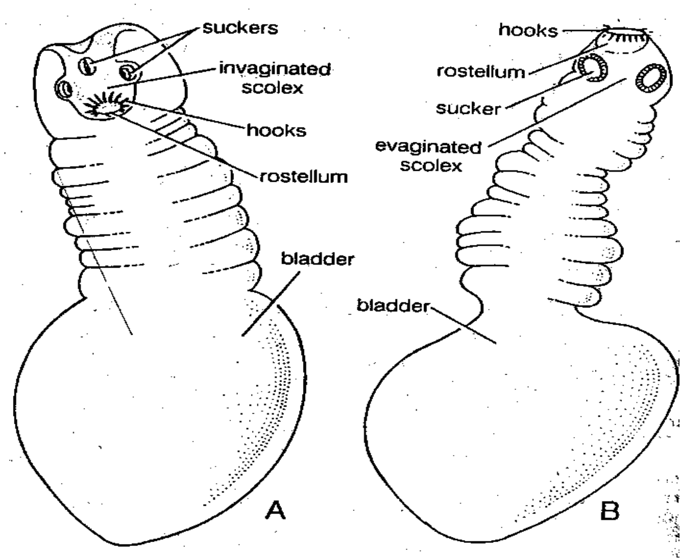


Fig. 4.15 *Cysticercus larva*

4.3*Schistosoma* (Blood fluke)

4.3.1 General characters:

1. They are commonly known as blood Flukes (see fig. no. 4.16).
2. They are parasitic in nature.*Schistosoma* lives in the hepatic portal system and mesenteric vessels of man.
3. They are greyish or pinkish in color.
4. Adult males are 10 to 15 mm long. They have deep grooves called gynecophoric canals in which adult females typically lies. Males have many small nodules (tubercles) on their dorsal surfaces and many tiny spines on their suckers and inside their gynecophoral canals.
5. Females are longer (16-22 mm), smoother, and more slender. Both sexes have two suckers, one anterior and one ventral, which are used to grip venule walls.
6. Eggs, which can be found in the urine of infected hosts, are 110-170 um long by 40 to 70 mm wide.

7. It is the only trematode in which sex is separated while other trematodes are hermaphrodite.
8. Digestive system is simple and consists of oesophagus and forked intestine. Pharynx is absent.

4.3.2 Identifying characters:

Female of *Schistosoma* is found in the gynecophoric canal of the male

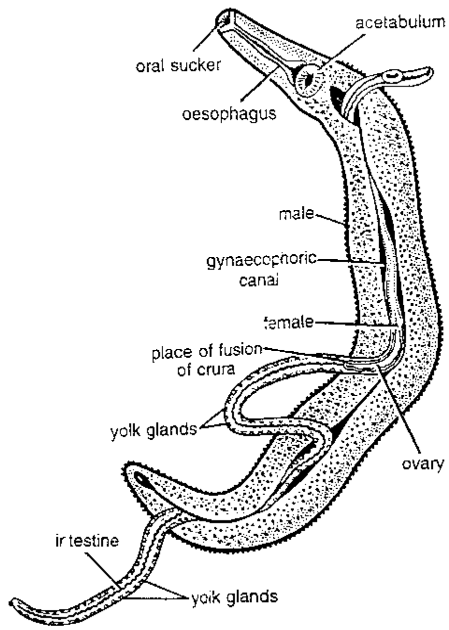


Fig. 4.16 *Schistosoma* (Blood fluke)

4.3.3 Systematic position:

Phylum ---Platyhelminthes - Flatworms, acoelomate

Class ---- Trematoda - Body wall without opidermis and cilia, Parasitic nature suckers are well developed.

Order ---- Digenea - Endoparasitic,many larval stages present, Two suckers without hooks

Genus ---- *Scistosoma*

Species--- *haematobium*

4.7 References:

1. R LKotpal: Text book of Zoology of Invertebrates, Rastogi Publication, 2007.

2. P. S. Verma: A manual of Practical Zoology Invertebrates, S. Chand Publication.

3. S. S. Lal: Practical Zoology Invertebrate, Rastogi Publication.

4. B N Pandey: Animal diversity volume 1, Tata McGraw Hill Education Private Limited.

5. V P Agrawal and L D Chaturvedi: A text book of Zoology, Jagmander Book Agency.

UNIT-5 PHYLUM: ASCHELMINTHES (Round worms)

General Characteristics:

1. Round worms inhibit aquatic and terrestrial environment and are well known parasites.
2. Bilaterally symmetrical and unsegmented worms.
3. Triploblastic and pseudocoelomate animals with organ system grade of body organization.
4. Body size mostly small, some microscopic, while others few millimeters to a meters or even more in length.
5. Body mostly cylindrical or flattened, body wall with cuticle and cilia absent.
6. The digestive system includes straight and complete alimentary canal with mouth and anus, muscular and highly specialized pharynx
7. Respiratory and circulatory systems are absent.
8. Execratory system includes a system of canals, protonephridia or glandular organs or both for osmoregulation.
9. Nervous system simple and consists of a circumenteric nerve ring having anterior and posterior longitudinal nerves.
10. Sense organs are pits, papillae, bristles and eye spots.
11. Sexes are usually separate. Male is smaller than female.
12. Tubular gonads are continuous with their ducts. Paired female organs open by a vulva but a single male gonad opens into cloaca.
13. Asexual reproduction does not occur.
14. Eggs shelled cleavage determinate and spiral. Fertilization is internal and development is direct (no special larval stages).

Outline classification:-

Phylum- Aschelminthes

Class ↓

Nematoda

(Gr. nema=thread+eidos=form)

- Free living / parasitic, elongated roundworms.
- Cuticle and syncytial epidermis is present.
- Absence of Cilia, respiratory and circulatory systems.
- Digestive system complete with muscular pharynx and glands
- Dioecious female larger than male.

Order 1- Enploidea:

1. Cuticle not ringed,often with cuticular bristles.
2. Anterior end with six labial papillae.
3. 10-12 bristles in 1 or 2 circlets.
4. Examples : *Enoplus, Anticoma*

Order 2 – Dorylaimoidea

1. Cuticle smooth without bristles.
2. Anterior end with 2 circlets of papillae of 6 and 10 each.
3. Rear part of pharyns enlarged.
4. Examples : *Dorylamius, Tylencholaimus*

Order 3 – Mermithoidea

1. Smooth and filiform, parasitic mainly in insects in juvenile stages or free living as adults in soil or water.
2. Head sense organs reduced to usually 6 papillae.
3. Pharynx long and blind. Intestine also blind which serves as food store.
4. Examples : *Mermis,Paramermis*

Order 4 – Chromadoroidea

1. Aquatic nematodes having smooth or ringed cuticle.
2. Cuticle heavily ornamented with bristles, knobs, punctations etc.
3. Pharynx with a posterior bulb.
4. Examples : *Paracytholaimus, Paracanthonchus*

Order 5 – Araeolaimoidea

1. Cuticle smooth, sometimes with bristles.
2. Labial papillae present.
3. Anterior end usually with 4 cephalic bristles.
4. Examples : *Plectus, Odontophora*

Order 6 –Monhysteroidea

1. Cuticle smooth or slightly ringed, often with bristles.
2. Anterior end with 4, 6 or 8 bristles, or multiples thereof.
3. Examples : *Cylindrolaimus, Siphonolaimu*

Order 7 – Desmoscalecoidea

1. Cuticle heavily ringed with prominent bristles throughout or in restricted areas.
2. Anterior end with 4 bristles.
3. Marine nematodes.
4. Examples : *Desmoscolex, Tricoma*

Order 8 – Rhabditoidea

1. Free living or parasitic with ringed or smooth cuticle.
2. Pharynx with posterior bulb.
3. Caudal glands absent.
4. Examples : *Rhabditis, Diploscapter*

Order 9 – Rhabdiasoidea

1. Smooth nematodes without definite pharyngeal bulb.
2. Hermaphrodite, parthenogenesis occurs.
3. Parasitic stages in animals.
4. Examples : *Entomelas, Rhabdias*

Order 10 – Oxyuroidea

1. Pharynx with a posterior bulb.
2. Caudal alae forming a cuticular bursa.
3. Females with a long pointed tail and males with 1 spicule or 2 equal spicules.
4. Examples : *Enterobius, Oxyuris*

Order 11 – Ascaroidea

1. Mouth surrounded by three prominent lips.
2. Tail of female blunt; male without caudal alae and possess two equal or nearly equal spicules.
3. Buccal capsule absent.
4. Example: *Ascaris*

Order 12 – Strongyloidea

1. Mouth without conspicuous lips but often with leaf crowns.
2. Males with copulatory bursa supported by muscular rays. Typically 13 in numbers.
3. Pharynx without bulb.
4. Examples : *Ancylostoma, Necator*

Order 13 – Spiruroidea

1. Mouth with two lateral lips; sometime 4 or 6 small ones.
2. Males without bursa spicules unequal and dissimilar.
3. Pharynx without bulb.
4. Examples : *Thelazia, Rictularia*

Order 14 – Dracunculoidea

1. Without definite lips or cuticularized buccal capsule.
2. Males with equal filiform spicules.
3. Vulva not functional.
4. Examples : *Dracunculus, Micropleura*

Order 15 – Filiarioidea

1. Filiform worms without lips.
2. Buccal capsule small or rudimentary.
3. Bursa wanting, spicules unequal and dissimilar.
4. Examples: Wuchereria*, Loa loa.*

Order 16 – Trichuroidea or Trichinelloidea

1. Body filiform anteriorly.
2. Mouth without lips.
3. Provided with a cirrus, spicules if present one only.
4. Examples: *Trichinella, Trichuris*

Order 17 – Dioctophymoidea

1. Moderate to very long sized nematodes.
2. Mouth without lips surrounded by 6, 12 or 18 papillae.
3. Males with muscular bursa but without rays.
4. Examples : *Dictyophyme, Hystrichis*

5.3 *Ascaris lumbricoides* (Round worm)

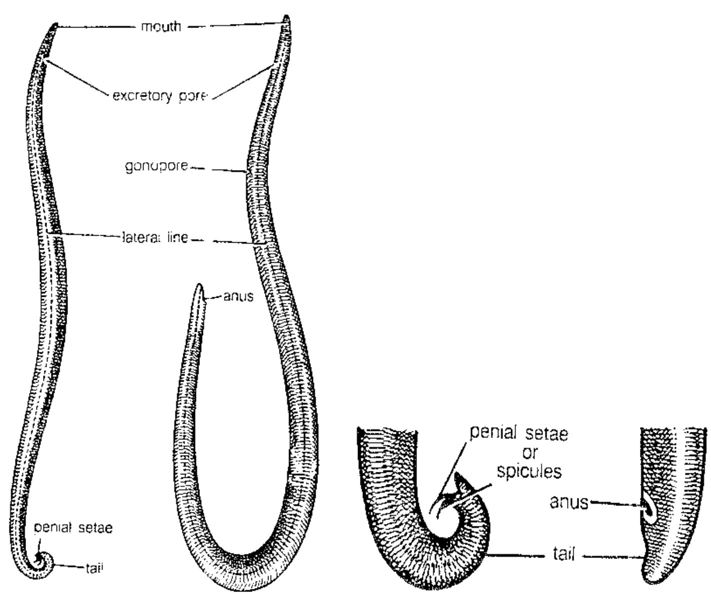
5.3.1 General characteristics:-

1. *Ascaris*is a common endoparasite in the small intestine of the man.

2. It causes ascariasis in man especially in children. Infection by eating raw & uncooked vegetables.
3. Shows sexual dimorphism with separate male and female individuals. Male measures 15 to 30 cm and female 20 to 35 cm in length.
4. Body is elongated, cylindrical, pointed at both ends.
5. Surface of the body is marked with four longitudinal lines.
6. Mouth provided with a median dorsal and a pair of symmetrical sub median ventral lips.
7. Excretory pore is small and lies at the ventral surface with distance of 2 mm away from the anterior end.
8. Tail end of male is ventrally curved containing cloacal aperture, through which two equal isospicules projections.
9. Female genital aperature lies about one-third of the body from the anterior end.
10. Life history is simple and no intermediate host.

5.3.2 Identifying characters:-

Unsegmented, cylindrical body, posterior end is curved in male, female has pointed tail.



(A) (B) (C)

Fig. 5.1 *Ascaris lumbricoides*

(A) Male(B) Female (C) Posterior end of male and female Ascaris

(B)

5.3.3Systematic position:

Phylum ---Aschelminthes -Unsegmented, Pseudocoelomate

Class --- Nematoda -Cilia absent, round worm, alimentary canal straight

Order ---Ascaroidea - Living in Intestine of vertebrates, mouth with three lips, Pharynx without a posterior bulb.

Genus -*Ascaris*

Species –*lumbricoides*

5.4 *Ancylostoma duodenale*:-

5.4.1 General characteristics:

1. *Ancylostoma duodenale* is commonly called as **hook worm**.
2. It is found asendoparasite in the intestine of man.
3. Mature worm is cylindrical in shape, narrow anteriorly and white or ivory grey in color.
4. Males measures 8-11 mm in length where as female measures 10-13 mm in length.
5. Anterior end in both sexes is bent dorsally and is provided with large and cup shaped buccal capsule for attachment with mucous membrane of the intestine.
6. Buccal cavity is oval and the buccal capsule is made of articulated grooved portion. Capsule contains a pair of chitinous plates and a median dental process or teeth.
7. Digestive system consists of mouth, pharynx, intestine, rectum and anus in female cloaca in males.
8. Exceratory pore mid ventral in position just behind the nerve ring
9. Female has pointed tail end while Male is provided with a copulatory bursa which is broader than long and supported by fleshy rays.
10. Fertilization is internal and occurs in the intestine of host.
11. Fertilized eggs are passed out with the faeces.
12. Mode of infection is penetration of skin of host by the infective larval stage.

5.4.2 Identifying characters:

It contains teeth in buccal capsule, bursa in males.

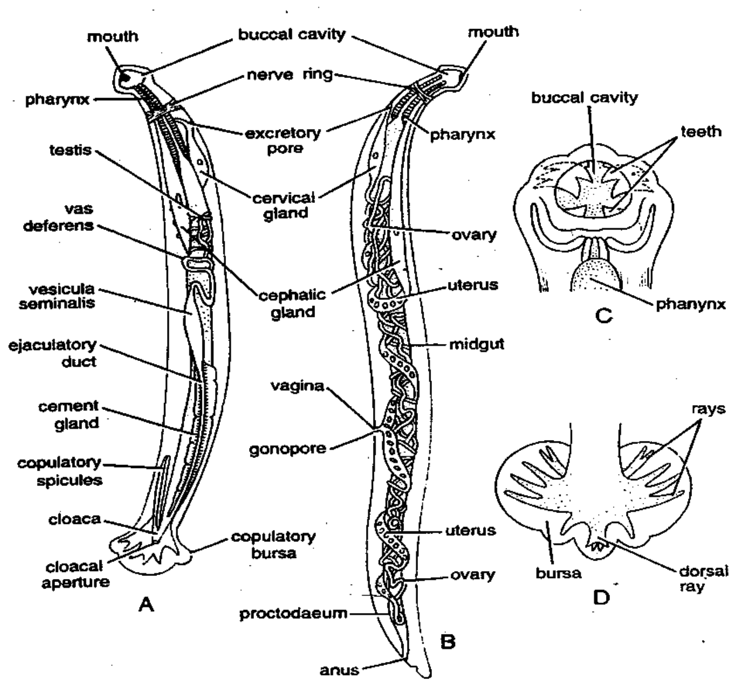


Fig. 5.2 *Ancylostoma duodenale*
(A) Adult male (B) Adult female (C) Anterior end (D) Posterior end

5.4.3 Systematic position:-

Phylum ---Aschelminthes -Unsegmented or superficially segmented, Pseudocoelomate Vermiform

Class --- Nematoda- cilia absent, alimentary canal straight

Order --- Strongloidea - Living in Digestive Tract of vertebrates, female with ovijecters,male with a copulatorybursa,pharynx without bulb.

Genus ---*Ancylostoma*

Species--- *duodenale:*

5.5***Dracunculusmedinensis*** (guinea worm)

5.5.1 General characteristics:-

1. Worms are cylindrical, elongated with blunt anterior end. Posterior extremity hooks like for anchorage in sub-cutaneous tissues.
2. Males measures 12 to 29 mm in length and 0.4 mm in breadth while females arevmuch larger than male measuring 70 to 120 mm in length & 0.9 to 1.7 cm in breadth
3. Its anterior part of pharynx is muscular but posterior part is glandular.
4. The sexes are different.
5. Posterior end of male is curved having 4 pairs of pre-anal and 6 pairs of post-anal papillae, pair of equal filiform copulatory spicules and gubernaculums. The tail end of female is straight.

5.5.2 Identifying character:-

Since tail end of male contains 10 pairs of caudal papillae and all above features, hence it is *Dracunculusmedinensis.*

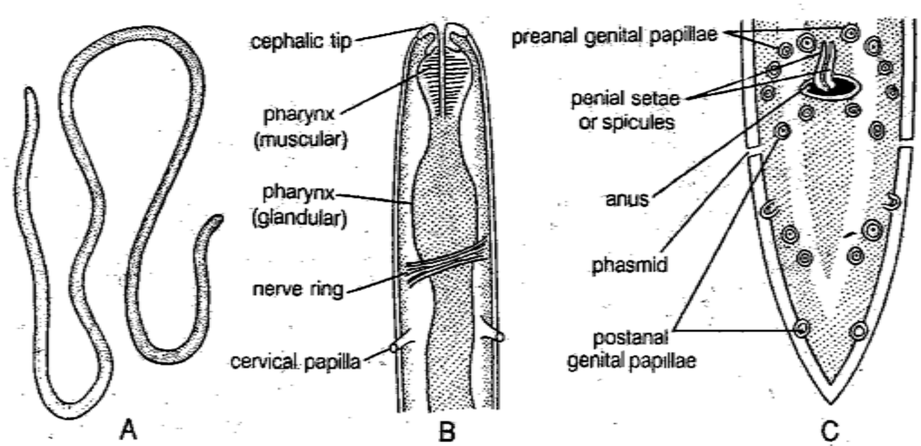


Fig. 5.3 *Dracunculusmedinensis*
(A) Adult worm (B) Anterior end of male (C) Ventral view of tail of male

5.5.3 Systematic position:

Phylum ---Aschelminthes-Unsegmented or superficially segmented, Pseudocoelomate Vermiform

Class --- Nematoda- cilia absent, alimentary canal straight

Order ---Dracunculoidea - Parasitic, mouth without lips, buccal capsules cuticularized, Pharynx muscular and glandular without bulbs

Genus --- *Dracunculus*

Species --- *medinensis*

5.6 *Wuchereriabancrofti*:-

5.6.1 General characteristics:-

1. They are found in lymph glands or ducts in human.
2. Adult worm are filiform & cylindrical in shapes with both ends tapering and terminating bluntly, creamy white in color.
3. Head slightly swollen and provided with two rows of small sessile papillae.
4. Mouth is unarmed and devoid of buccal cavity.
5. They show sexual dimorphism by tail ends. Male has the caudal end curved having unequal spicules in spiracular sheaths (gubernaculum) 12 pairs of caudal papillae while female bearing the vulval opening just behind the anterior extremity of the body.
6. Male is about 40 mm in length and Female is about 80 to 100 mm in length.
7. Female worms give birth to first stage larva microfilaria (juveniles) which are surrounded by delicate membrane or sheath.
8. Microfilaria is long, cylindrical provided with a striated cuticle.
9. Microfilariae are discharged into lymph vessels and are then passed into the blood vessels of the periphery between 10.00 pm and 2.00 am.
10. Culex mosquito serves as intermediate host.
11. Culex sucks blood from human. Then Microfilariae are also transferred.
12. After this development takes places in stomach and thoracic muscles of the mosquito.
13. It causes a disease which is known as Filariasis (Elephantiasis).

5.6.2 Identifying characters:-

12 pairs of caudal papillae are present6 in male at tail end.

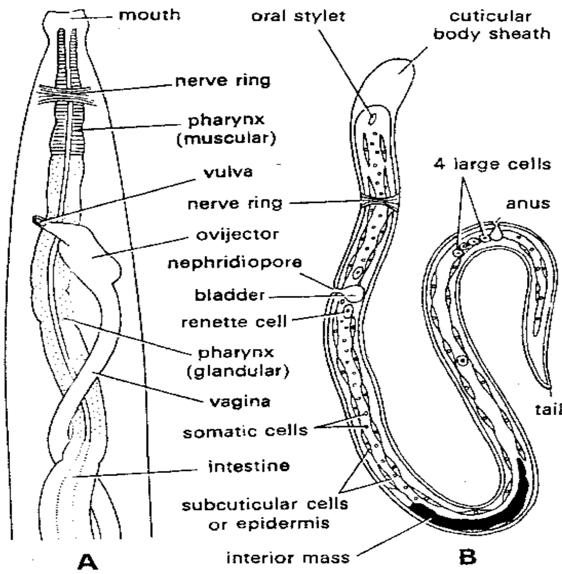


Fig. 5.4*Wuchereriabancrofti*
(A) Anterior part of female W. bancrofti (B) Microfilaria of W. bancrofti

5.6.3 Systematic position:-

Phylum ---Aschelminthes - Unsegmented or superficially segmented, Pseudocoelomate Vermiform

Class ---Nematoda -Cilia absent, alimentary canal straight

Order ---Filarioidea - Mouth devoid of lips but with buccal capsule,bursa absent.

Genus --- *Wuchereria*

Species ---*bancrofti*

5.7 *Trichinellaspiralis* (Trichina worm):-

5.7.1 General characteristics:-

1. *Trichinellaspiralis* is an endoparasite found in the intestine of man, pig , rat, black bear , polar bear and other vertebrates.andencysted form in voluntary muscles of host like limbs, chest, diaphragm, tongue, eye and neck.
2. Female worm are larger than male worm. Male worm is 1.4 -1.6 mm in length and Female worm is 3-6 mm in length.

3. Male has pointed anterior end and fleshy posterior end provided with a large conical papillae while female has pointed anteriorly and fleshy posteriorly.
4. A new host acquires infection by eating raw or improperly cooked flesh containing encysted larva.
5. The cyst gets dissolve by digestive juice in stomach or intestine of host.
6. Larvae are liberated in the intestine of host. A further larva penetrates into the mucosa of small intestine.
7. Larva undergoes a series of moults to become adult in small intestine within 2 days.
8. The mouth leads into pharynx which contains large granular cells, called stichosome.
9. Vulva is situated anteriorly.
10. Copulation takes place in intestine. After copulation male dies and pass out of host body.
11. Female then increase to their maximum size and penetrate more deeply into the intestine wall.
12. Female produce large number of small juvenile worms in the intestinal wall which are distributed throughout the body by the lymphatic and blood streams.
13. The juvenile worms penetrate chiefly into the ends of skeletal muscles such as diaphragm and intercostalsmuscle etc , and form lemon – shaped cysts.
14. It causes a serious and dreaded disease known as Trichinosis.
15. Diarrohea, nausea, abdominal pain, hypereosinophilia, thrombosis, muscular pain are the symptom associated with Trichinosis.

5.7.2 Identifying characters:

It shows coiled larva in cyst, hence it is called *Trichinellaspiralis*

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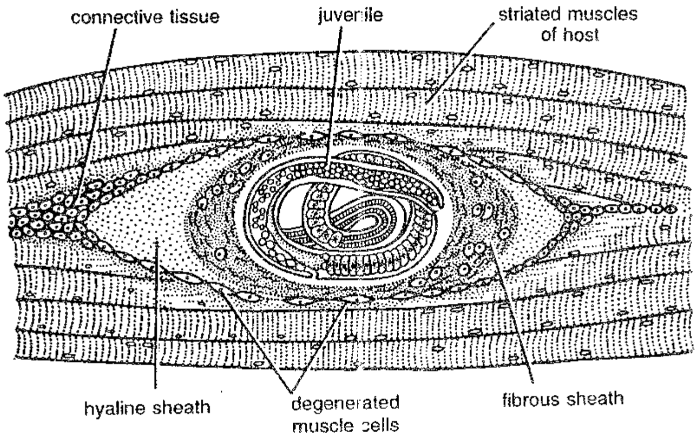


Fig. 5.5*Trichinellaspiralis– Encysted larvae*

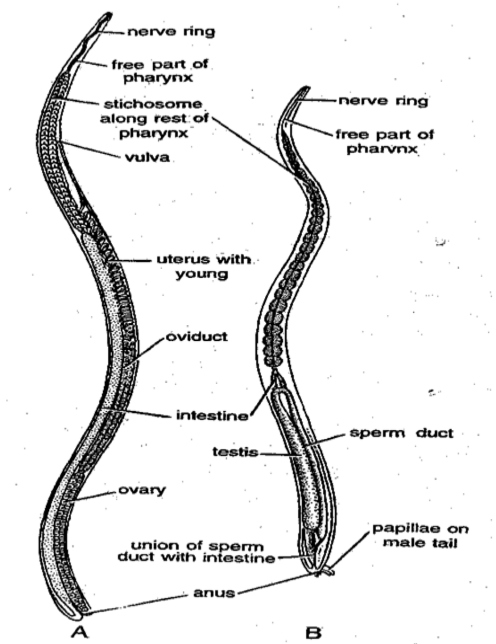


Fig. 5.6*Trichinellaspiralis*
(A) Female (B) Male

5.7.3 Systematic position:-

Phylum ----Aschelminthes-Unsegmented or superficially segmented, Pseudocoelomate Vermiform

Class --- Nematoda- cilia absent, alimentary canal straight

Order --- Trichuroidea -Mouth devoid of lips, pharynx with stichosome, male with Copulatory apparatus.

Genus --- *Trichinella*

Species ---*spiralis*

5.8 *Enterobius vermicularis:-*

5.8.1 General characteristics:-

1. *Enterobius vermicularis* is commonly known as Pin Worm of Man.
2. They lives in caecum, appendix and at the junction of small and large intestines.
3. Female worm are larger than male worm. Male worm is 2 to 5 mm long, with a diameter of 0.1 to 0.2 mm while female is 8 to 13 mm long with a diameter of 0.3 to 0.5 mm.
4. Tail end of Female is long and pointed while that of male is curved, blunt and with a bursa like expansion and a single spicule.
5. Worms are slender and cream coloured.
6. Male is monarchic and female didelphic.
7. There incidence is greater in women and children.
8. No Intermediate host is involved.
9. Female migrates to anus in night and deposits eggs.
10. This cause severe itching at anal and perianal regions. Host is tempeted to scratch.
11. Tiny eggs about 55 µ by 30 µ. Each egg contains a developed larva.
12. Finger and finger nails gets in contact as soon as host scratch.
13. The larva enters the gut with the food to cause a reinfection.
14. Eggs hatch in duodenum. Larva reach small intestine, where they moult twice and become adults.
15. Loss of appetite, insomnia, hysteria, restlessness and inflammation of mucous membrane of infected regions are the symptoms of infection with pin worm.

5.8.2 Identifying characters:

This parasite contains cervical alae, bulbous oesophagus.

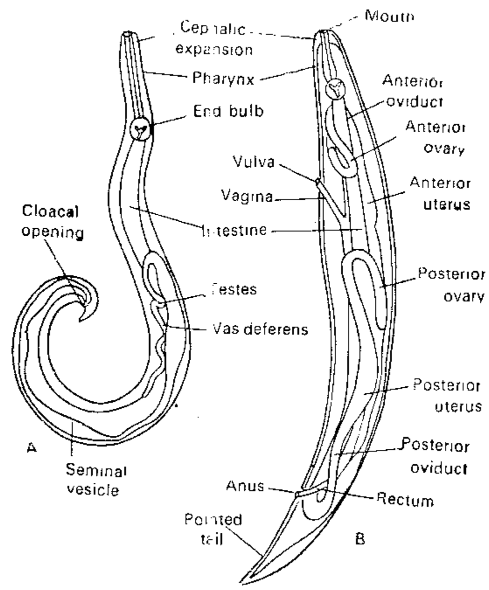


Fig. 5.7--- *Enterobius vermicularis*
(A) Male (B) Female

5.8.3 Systematic position:

Phylum ---Aschelminthes-Unsegmented or superficially segmented, Pseudocoelomate Vermiform

Class --- Nematoda- Unsegmented body, cilia absent, alimentary canal straight

Order --- Rhabditea- 3 or 6 lips, pharynx with a posterior bulb

Genus --- *Enterobius*

Species --- *vermicularis*

5.12 References:

1. R L Kotpal: Text book of Zoology of Invertebrates, Rastogi Publication, 2007.
2. P. S. Verma: A manual of Practical Zoology Invertebrates, S. Chand Publication.
3. S. S. Lal: Practical Zoology Invertebrate, Rastogi Publication.
4. B N Pandey: Animal diversity volume 1, Tata McGraw Hill Education Private Limited.
5. V P Agrawal and L D Chaturvedi: A text book of Zoology, Jagmander Book Agency.

UNIT 06: PHYLUM ANNELIDA

Classification:

Class1. Polychaeta (Gr., Poly=many+ chaete=bristles)

1. Polychaeta is fresh water and marine.

2. Body is segmented and elongated.

3. Head consists of prostomium and peristomium and bear tentacles, eyes, palps, and cirri etc.

4. Setae numerous, or lateral parapodia.

5. Sexes are separate.

6. Trochophore larva present.

Order 1 Errantia:

1. These are motile and free living polychaetes.

2. Except for head and anus the rest of the body is divisible into segments.

3. Head well developed with eyes and tentacles.

4. Pharynx is protrusible and contains jaws and teeth.

5. Parapodia, provided with cirri are equally developed throughout.

Examples: *Aphrodite, Polynoe, Phyllodoce, Nereis, Glycera, Syllis, Eunice, Diopatra, Histriobdella*.

Order 2. Sedentaria:

1. Tube-dwelling and burrowing forms.

2. Body is made up of two or more regions, with dissimilar segments and parapodia.

3. Head poorly developed without eyes and tentacles.

4. Pharynx is non protrusible without jaws and teeth.

5. Gills when present localized to anterior segments.

Examples: *Chaetopterus, Arenicola, Owenia, Sabella, Sabellaria, Terebella, Amphitrite, Pomatoceros, Spirobis, Serpula*.

Class 2. Oligochaeta (Gr., Oligo=few+ chaete=bristles)

1. Some freshwater and mostly terrestrial forms.

2. Body with conspicuous external and internal segmentation.

3. Head indistinct, without sensory organs.

4. Parapodia are absent.

5. Setae are usually arranged segmentally.

6. Hermaphrodite. No larval stage.

Order 1. Archaeoligochaeta

1. They are mostly fresh water.

2. Body comprises of few segments.

3. Setae are present.

4. Poorly developed gizzard.

5. Female reproductive openings present after that of male reproductive openings.

6. Reproduction asexual and sexual.

Examples: *Tubifex, Aelosoma, Nais, Chaetogaster, Dero*.

Order 2. Neooligochaeta:

1. Mostly terrestrial earthworms.

2. Body consists of many segments.

3. Setae are present.

4. Well developed gizzard.

5. Male reproductive openings present after that of female reproductive openings.

6. Reproduction sexual.

Examples*: Pheretima, Megascolex, Allolobophora, Lumbricus, Eisenia, Dendrobaena.*

Class 3. Hirudinea: (L., hirudo, leech)

1. Mostly freshwater but some are found in marine or terrestrial environments.

2. Generally ectoparasitic, blood sucking or carnivorous.

3. Body is elongated, dorso-ventrally flattened or cylindrical.

4. Parapodia and setae are absent.

5. Usually suckers are present.

6. Hermaphrodite.

7. Reproduction sexual.

8. Development is direct without free-swimming larval stage.

Order 1. Acanthobdellida:

1. Mostly parasitic on the fins of salmon fishes.

2. Body comprises 30 segments only.

3. Body cavity is spacious and incompletely divided by septa.

4. Setae present in first 5 anterior segments.

5. Acanthobdellida forms a connecting link between Oligochaeta and Hirudinea.

Example: *Acanthobdella*.

Order 2. Rhychobdellida

1. Only aquatic leeches.

2. Each typical body segment consists of 3, 6 or 12 rings.

3. Blood is colourless.

4. Coelom is reduced to sinuses without botryoidal tissues.

Examples: *Glossiphonia, Pontobdella, Pisciola, Branchellion*.

Order 3. Gnathobdellida

1. Freshwater and terrestrial forms.

2. Body segments typically consist of 5 rings of annuli.

3. Proboscis is absent.

4. Blood is red-coloured.

Examples: *Hirudinaria, Haemopis, Hirudo, Herpobdella*.

Class 4 Archiannelida:

1. Exclusively marine forms.

2. Body elongated and worm-like.

3. Parapodia are usually absent.

4. Hermaphrodite.

Examples: *Protodrillus, Nerilla, Polygordius, Saccocirrus*.

Class 5 Echiuroidea

1. Marine, found between rocks in shallow water.

2. The body is more or less cylindrical.

3. Parapodia absent.

4. Sexes are separate.

5. Larva trochophore.

Examples: *Echiurus, Bonellia*.

Class 6 Sipunculoidea:

1. Sipunculoidea is found in sand or mud.

2. Body is elongated, grayish or yellowish in colour without segmentation.

3. Parapodia are absent.

4. Sexes are separate.

5. Larva similar to trochophore.

Examples: *Sipunculus, Phascolosoma*.

Class 7 Priapulida

1. Found widely distributed at moderate depths, burrowing in sand or mud.

2. Body worm-like, cylindrical, unsegmented with superficial segmented trunk.

3. Mouth is anterior and anus is posterior.

4. Sexes are separate.

5. Development is unknown.

Example: *Priapulus*.

Class 8 Myzostomaria

1. Ecto or endoparasite.

2. Body is flat, worm-like, unsegmented and oval or disc-like in shape.

3. Five pairs of parapodia.

4. Protandric hermaphrodites.

5. Larva trochophore.

Example: *Myzostoma*.

IDENTIFICATION, SYSTEMATIC POSITION UP TO ORDER AND GENERAL STUDY OF NEREIS:

Systematic position:

Phylum Annelida

Class Polychaeta

Order Errantia

Genus *Nereis*

Comments:

1. *Nereis* (Fig. 1) is commonly called rag worm.
2. The body is long, slender, elongated, dorso-ventrally flattened segmented and is divisible into head, trunk and pygidium.
3. Head consists of two parts, the prostomium and peristomium. Prostomium bears a pair of tentacles, two pairs of eyes and a pair of short two jointed palps. Peristomium bears four tentacles and a slit-like mouth.

4. Trunk is made up of several segments, each bearing a pair of lateral parapodia which are locomotory organs. Setae project beyond the outer margin of each parapodium.

5. Pygidium or anal segment is without parapodia but bears a pair of appendages known as anal cirri and a terminal anus.

6. Respiration happens via blood capillary network of parapodia.

7. Aimentary canal is straight and extends from mouth at the anterior end to the anus at the posterior end.

8. Sexes separate. Fertilization is external.

9. The sexual phase of *Nereis* is known as *Heteronereis*.

Habit and habitat:

Nereis is found in burrows in sand or rocks in intertidal and shallow marine waters.

Distribution:

Nereis is cosmopolitan in distribution and found in coastal waters of Europe, North Atlantic, Pacific oceans and U.S.A.

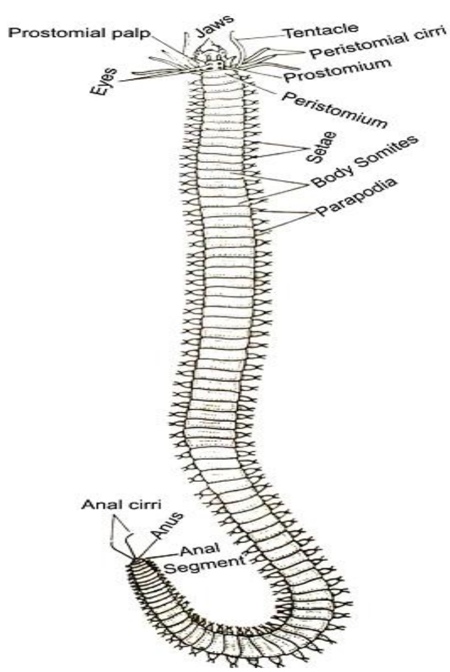


Fig. 1. *Nereis*

HETERONEREIS

Systematic position:

Phylum	Annelida
Class	Polychaeta
Order	Errantia
Genus	*Heteronereis*

Comments:

1. *Heteronereis* (Fig. 2) is the sexual phase of *Nereis*.

2. The body of *Heteronereis* is divisible into an anterior atoke or asexual region and a posterior epitoke or sexual region.

3. It comes out to the water surface and leads an active free swimming life.

4. Eyes become greatly enlarged and highly sensitive to light.

5. The peristomial cirri become longer.

6. Parapodia become enlarged, develop additional foliaceous outgrowths and setae become oar-shaped which help in active swimming.

7. Due to excessive development of gonads, the muscles and alimentary canal are reduced.

8. There is no marked sexual dimorphism in most species.

Habit and habitat:

Heteronereis is a free-swimming worm found in sea.

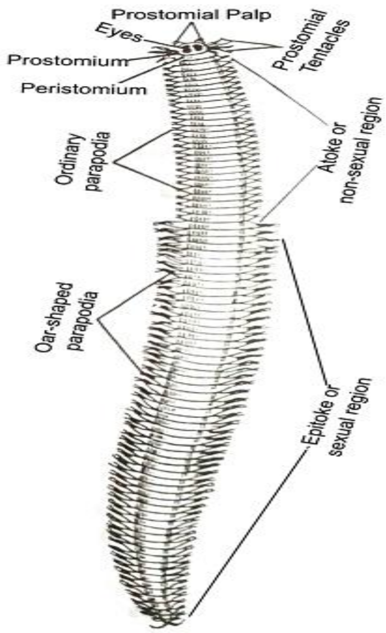


Fig. 2. *Heteronereis*

APHRODITE

Systematic position:

Phylum Annelida

Class Polychaeta

Order Errantia

Genus *Aphrodite*

Comments:

1. *Aphrodite* (Fig. 3) is commonly called as sea mouse.
2. It measures about 12 cm in length.
3. Body is short, oval and dorso-ventrally flattened.
4. Ventral surface is flat, segmented and forms a creeping sole.
5. Stiff setae and hollow bristles are present on the dorsal surface.
6. Segments clearly visible on the underside.
7. Head is small, situated anteriorly beneath the dorsal felt and bears a single small median tentacle and two large lateral palps.
8. Intestine is characterized by long branching segmental caeca which digest minute food particles.

9. Respiration takes place through dorsal body surface.

10. Anus is situated at the posterior extremity on the dorsal surface.

11. Sexes are separate and fertilization is external.

Habit and habitat:

Aphrodite is a marine burrowing form found just below the intertidal zone usually on sandy muddy bottoms.

Distribution:

It is found in both sides of Atlantic and in the Mediterranean Sea.

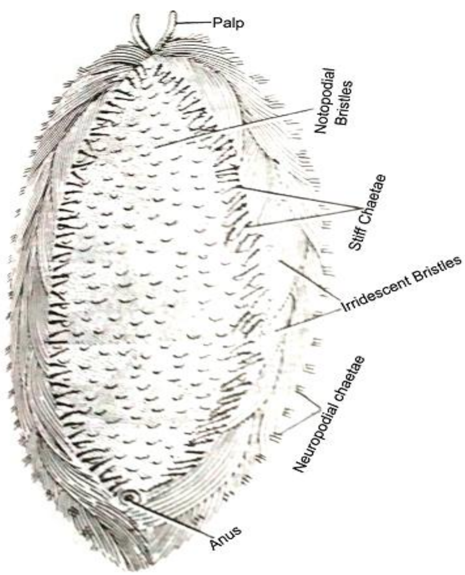


Fig. 3. *Aphrodite*

ARENICOLA

Systematic position:

Phylum	Annelida
Class	Polychaeta
Order	Sedentaria
Genus	*Arenicola*

Comments:

1. *Arenicola* (Fig. 4) is commonly called lug-worm or lobe-worm.

2. Body is cylindrical, segmented, elongated and worm-like measuring up to 25 cm in length.

3. Body consists of three regions: anterior, middle and posterior.

4. Anterior region comprises prostomium, peristomium and six segments bearing chaetae and parapodia.

5. Middle region is made up of thirteen segments bearing parapodia and gills.

6. Posterior region comprises of variable number of segments devoid of parapodia, setae and gills.

7. Mouth lies ventral to the prostomium.

8. The anus opens through the last segment.

9. Sexes are separate with external fertization.

10. *Arenicola* is generally used as bait in fishing.

Habit and habitat:

Arenicola is a marine worm, lives in burrows deep into the sandy sea bottom or intertidal areas.

Distribution:

Arenicola is found in Europe and Northern America.

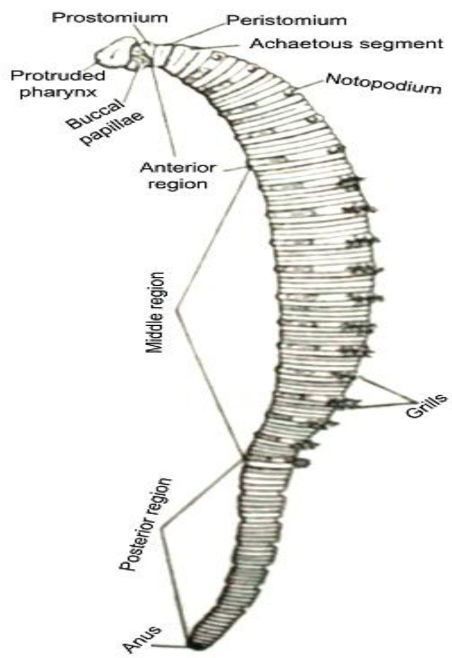


Fig. 4. Arenicola

PHERETIMA

Systematic position:

Phylum	Annelida
Class	Oligochaeta
Order	Neooligochaeta
Genus	*Pheretima*

Comments:

1. *Pheretima* (Fig. 5) is commonly called earthworm.

2. Body is bilaterally symmetrical, narrow, long, elongated and cylindrical measuring upto 150 mm in length.

3. Anterior end is tapering and posterior end is blunt.

4. Body is divided into 100-120 ring-like segments by a distinct series of annular grooves.

5. Each segment is provided with setae arranged in a ring with each setae arising from a setigerous sac of the skin. The setae help in locomotion by holding the earth.

6. Mouth is crescentic aperture situated just below the prostomium.

7. The clitellum is a circular band of glandular tissue which completely surrounds the segments from 14^{th} to 16^{th} segment.
8. Hermaphrodite.
9. A pair of male genital pore is situated ventrally in the eighteenth segment while female genital pore are situated at the ventral surface of fourteenth segment.
10. Anus is situated at the terminal end of the last body segment called anal segment.
11. Reproduction is usually sexual.
12. Development takes place in cocoons.
13. Earthworm is used as bait in fishing and as food by many uncivilized people. It also has use in medicines, education, experiments and in agriculture as producer of organic fertilizer.

Habit and habitat:

Pheretima are burrowers found in the soil rich in decaying organic matters usually in pastures, lawns, gardens, irrigated farm lands, near the banks of ponds, lakes and rivers.

Distribution:

Found all over world.

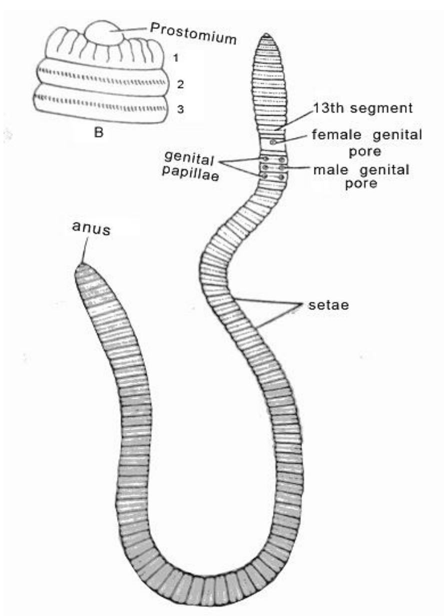


Fig. 5. Pheretima

PONTOBDELLA

Systematic position:

Phylum	Annelida
Class	Hirudinea
Order	Rhynchobdellida
Genus	*Pontobdella*

Comments:

1. Body is rough, cylindrical, elongated and has warts arranged in regular circles.

2. Body has a saucer-shaped anterior sucker and a cup-shaped posterior sucker.

3. Eyes, parapodia, jaws and gills are absent.

4. Proboscis is protrusible.

5. Crop has a single undivided caecum lying beneath the intestine.

6. Nephridia are absent.

7. Hermaphrodite.

8. Sexual reproduction is common.

Habit and habitat:

Pontobdella (Fig. 6) is a marine leech. Mostly ectoparasitic on sharks, rays and skates. A few species show parental care.

Distribution:

Pontobdella is found in Europe and U.S.A.

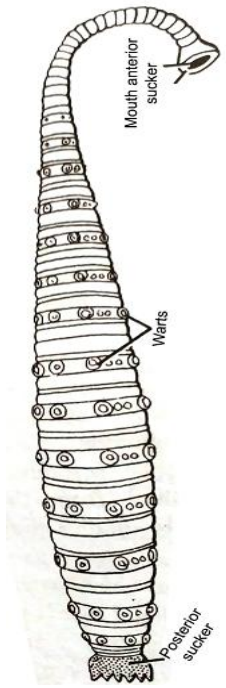


Fig. 6. *Pontobdella*

HIRUDINARIA

Systematic position:

Phylum Annelida

Class Hirudinea

Order Gnathobdellida

Genus *Hirudinaria*

Comments:

1. *Hirudinaria granulosa* (Fig. 7) is commonly called Indian cattle leech.

2. Body is soft, elongated, vermiform and bilaterally symmetrical with dorsal surface green and ventral surface orange yellow in colour.

3. During extension of the body is dorso-ventrally flattened while during contraction it is cylindrical.

4. Body of leech is divided into 33 segments. The segments are further divided into annuli or rings.

5. Anterior and posterior suckers are well developed. Anterior sucker is oval bearing triradiate mouth and is formed by the fusion of prostomium with a few somites of anterior region. The posterior sucker is circular in outline and forms a muscular disc at the posterior end. Both the suckers serve as powerful organs of adhesion and locomotion.

6. Five pairs of eyes are present on the dorsal side.

7. No special respiratory organs. Respiration happens via skin.

8. Locomotion by creeping/crawling on the surface.

9. Alimentary canal is a straight tube extending from mouth to anus. Small aperture or anus is situated mid-dorsally on the 26th segment at the root of the posterior sucker.

10. Excretory system consists of segmentally arranged seventeen pairs of nephridia arranged from six to twenty-two segments, opening by nephridiopores on the ventral surface.

11. Hermaphrodite.

12. Male genital aperture is situated mid-ventrally in the second and third annuli of 10th segment and female genital aperture between second and third annuli of 11th segment.

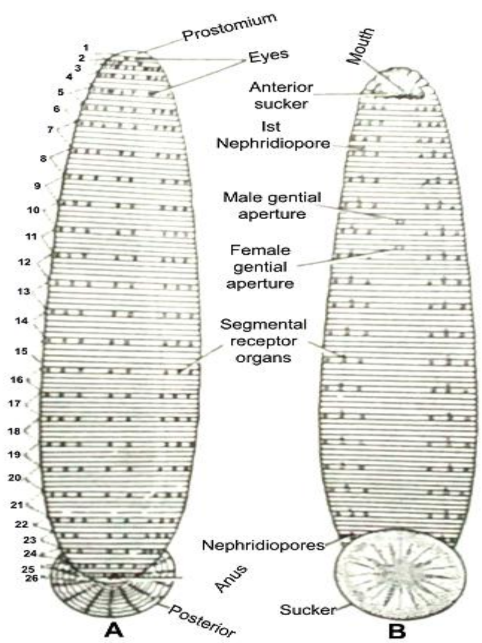
13. Sexual reproduction is common.

Habit and habitat:

Hirudinaria is found in freshwater tanks, ponds, lakes, slow streams and swamps. It is sangivorous (blood sucking) in habit.

Distribution:

Hirudinaria has cosmopolitan or worldwide distribution specially found in India and Myanmar.



A. Dorsal view B. Ventral view

Fig. 7. Hirudinaria granulose

T. S. Through Body Segment of *Nereis*

Comments:

1. Body wall consists of outer cuticle, inner epidermis and musculature (Fig. 8).

2. The cuticle is thin, chitinous and tough and has many minute pores.

3. Epidermis lies beneath the cuticle and is a single layer of cells comprising glandular, sensory and columnar cells.

4. Musculature consists of three types of muscles: circular, longitudinal and oblique muscles.

(i) Circular muscles form a continuous layer below the epidermis.

(ii) Longitudinal muscles consist of two dorso-laterals bundels and two ventro-laterals bundles.

(iii) Two pairs of oblique muscles connecting mid ventral body wall to the base of parapodia and helps in movement.

5. Parapodia lie on both the lateral sides distinguishing into notopodia and neuropodia.

6. Sections of dorsal ciliated organs, dorsal and ventral blood vessels, ventral nerve cord, gut, gonads, and nephridia can also be seen.

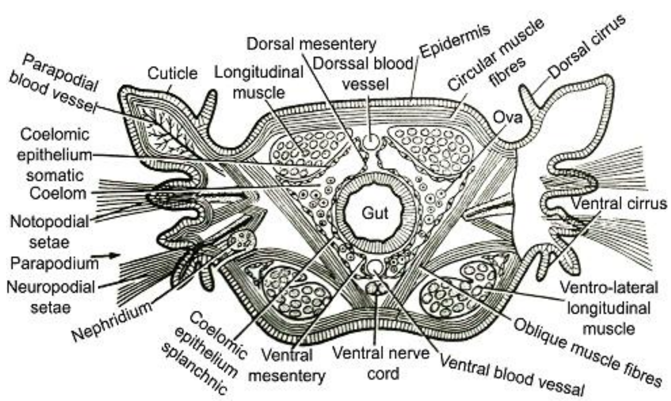


Fig. 8. T. S. through body segment of *Nereis*

Trochophore Larva of *Nereis*

Comments:

1. Trochophore larva (Fig. 9) is formed from gastrula and is top-like and transparent. It has a thin external ectodermal epithelium.

2. It has a mouth, a curved gut, ectodermal oesophagus, an endodermal stomach and an ectodermal anal opening.

3. It exhibits bilateral symmetry with the anterior end of the body broader than the posterior end.

4. The gut walls are lined by cilia.

5. Eyes lie below anterior apical sensory plate.

6. The apical organ forms the prostomium with brain, tentacles and eyes.

7. Above the mouth there is a strong locomotor ciliary band called Prototroch. The Prototroch encircles the body around the middle.

8. The gut is enclosed by a spacious blastocoel. The blastocoel has mesenchyme cells, larval mesoderm and a pair of larval nephridia. There is a statocyst near the nephridia.

9. Trochophore is called panktotrophic larva because it feeds on plankton and other microscopic organisms.

10. It drifts about in the sea swimming by its prototroch.

11. Segmentation of mesodermal bands marks the start of metamorphosis. Later the larva grows rapidly from the anal end externally marked with segmentation.

12. The larval setae are dropped, tentacles, palps and parapodia are formed and larval nephridia are replaced by permanent nephridia.

13. The young worm settles at the bottom of the sea and starts forming its burrow and gradually attains adulthood.

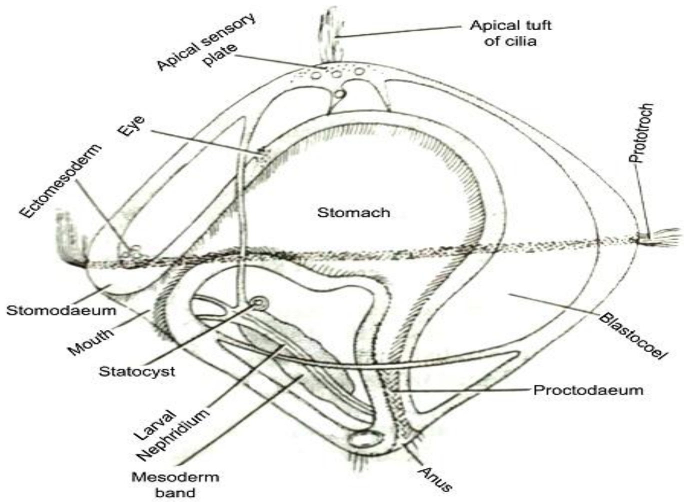


Fig. 9. Trochophore larva

Parapodium of *Nereis*

Comments:

1. Parapodia of *Nereis* (Fig. 10) are lateral, mucular, flattened outgrowths of the body wall.

2. The dorsal part (notopodium) bears dorsal cirrus and bundles of long setae.

3. The ventral part (neuropodium) bears a ventral cirrus and similar bundle of setae.

4. The notopodial and neropodial setae are embedded in the setigerous sacs.

5. Both notopodium and neuropodium are supported by dark coloured thick chitinous internal rod called aciculums.

6. Parapodia help in respiration and locomotion.

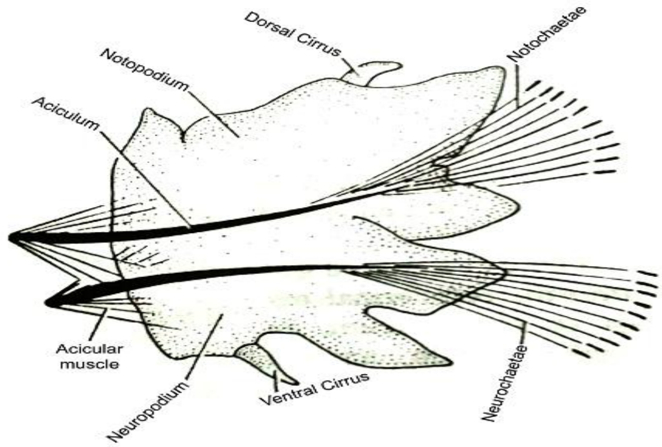


Fig. 10. Parapodium of *Nereis*

Parapodium of Heteronereis

Comments:

1. Body of Heteronereis (Fig. 11) is divided into anterior asexual region called atoke and posterior sexual region called epitoke. Parapodium of Heteronereis has similar structure as that of *Nereis* with following modifications.

2. Parapodium of the posterior sexual part of the body become large and develops foliaceous outgrowths.

3. Neruropodial lobe is larger than notopodial lobe.

4. Neuropodial and Notopodial setae become flattened and oar-shaped and are arranged in a fan-like manner.

5. Dorsal cirrus is larger than the ventral cirrus.

6. Changes in setae and lobes facilitate active swimming and efficient respiration.

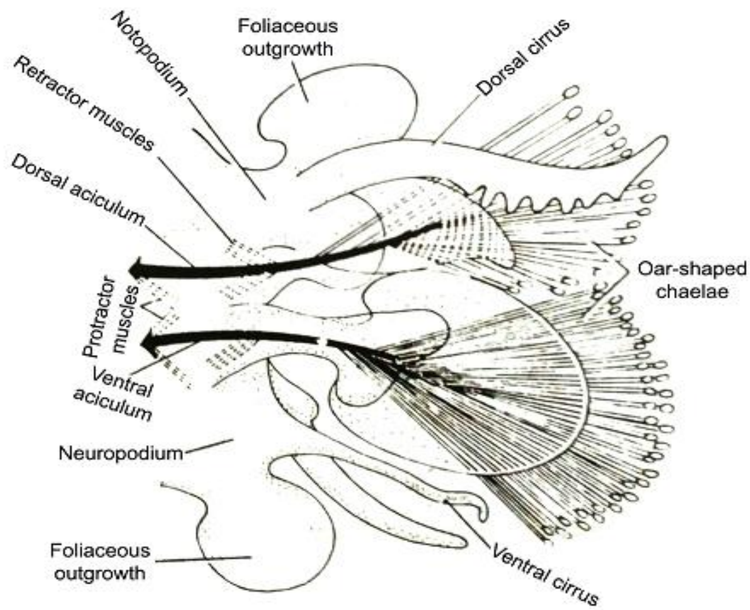


Fig. 11. Parapodium of *Heteronereis*

T. S. of *Hirudinaria* through Buccal Cavity

Comments:

1. Body wall consists of a cuticle membrane, epidermis, dermis and musculature (Fig. 12).

(i) Cuticle is delicate, thin, colourless and transparent membrane having pores.

(ii) Epidermis consists of narrow, elongated and hammer-shaped cells and single cell in thickness. It lies below the cuticle.

(iii) Dermis consists of fibrous connective tissue, short muscle fibres and haemocoelomic channels. It lies just below the epidermis.

(iv) Musculature consists of longitudinal, oblique, circular, dorso-ventral and radial muscles.

2. Sections of a medio-dorsal jaw and two sections of ventro-lateral jaws are seen embedded in the mucous membrane crypts of the buccal cavity.

3. Jaws are lined with thick cuticle.

4. Haemocoelomic capillary and anterior sucker glands are seen.

5. Botryoidal tissue is not seen in this section.

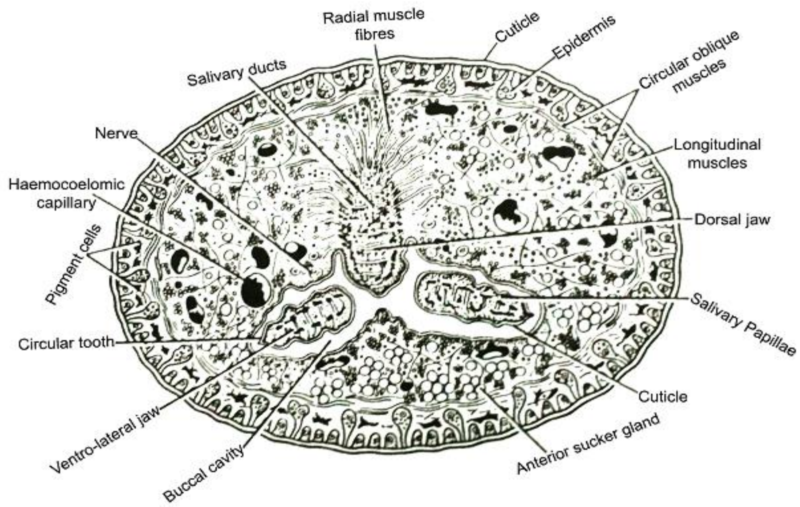


Fig. 12. T. S. *Hirudinaria* Through Buccal Cavity

T. S. of *Hirudinaria* through Crop with Diverticula

Comments:

1. Body wall consists of the following layers (Fig. 13):

(i) Cutile is the outermost layer of body wall. It is delicate, thin, colourless and transparent layer and has minute pores through which epidermal glands open out.

(ii) Epidermis is single layered and it comprises of elongated, narrow and hammer-shaped cells. It lies below the cuticle. It contains various epidermal glands: slime glands, sucker glands, prostomeal glands and clitellar glands.

(iii) Dermis lies below the epidermis and consists of fibrous connective tissue, short muscle fibres and haemocoelomic channels.

(iv) Musculature lies just below the dermis and consists of circular and oblique, longitudinal, dorso-ventral and vertical muscle fibres.

2. Sections of crop and its two diverticula are present in the centre. Botryoidal tissues lie around those diverticula.

3. A thin epithelial lining of prismatic cells cover the crop wall.

4. Sections of dorsal and lateral haemocoelomic channels, nephridia and ventral haemo-coelomic channel enclosing the ventral nerve cord can also be seen.

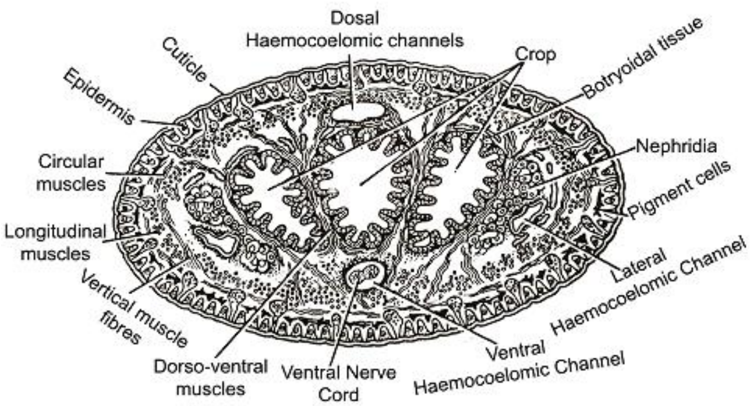


Fig. 13. T. S. of *Hirudinaria* through Crop with Diverticula

T. S. of *Hirudinaria* through Crop without Diverticula

Comments:

1. Body wall consists of usual layers which are as follows (Fig. 14):

(i) Cutile is the outermost layer of body wall. It is delicate, thin, colourless and transparent layer and has minute pores through which epidermal glands open out.

(ii) Epidermis is single layered and it comprises of elongated, narrow and hammer-shaped cells. It lies below the cuticle. It contains various epidermal glands: slime glands, sucker glands, prostomeal glands and clitellar glands.

(iii) Dermis lies below the epidermis and consists of fibrous connective tissue, short muscle fibres and haemocoelomic channels.

(iv) Musculature lies just below the dermis and consists of circular and oblique, longitudinal, dorso-ventral and vertical muscle fibres.

2. Sections of crop are present in the centre.

3. Botryoidal tissues are seen below the muscle layers

4. A thin epithelial lining of prismatic cells cover the crop wall.

5. Crop diverticula are absent.

6. Sections of lateral haemocoelomic channels, dorsal haemocoelomic channel, ventral haemocoelomic channel enclosing the ventral nerve cord are seen.

7. Sections of two large nephridial vesicles are seen on either side of the crop.

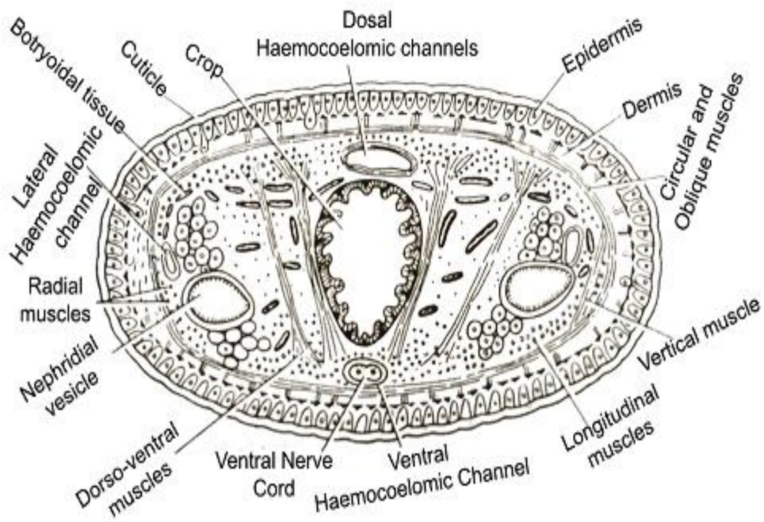


Fig. 14. T. S. of *Hirudinaria* through Crop without Diverticula

T. S. of *Hirudinaria* through Rectum and Posterior Sucker

Comments:

1. Body wall consists of the following layers (Fig. 15):

(i) Cutile is the outermost layer of body wall. It is delicate, thin, colourless and transparent layer and has minute pores through which epidermal glands open out.

(ii) Epidermis is single layered and it comprises of elongated, narrow and hammer-shaped cells. It lies below the cuticle. It contains various epidermal glands: slime glands, sucker glands, prostomeal glands and clitellar glands.

(iii) Dermis lies below the epidermis and consists of fibrous connective tissue, short muscle fibres and haemocoelomic channels.

(iv) Musculature lies just below the dermis and consists of circular and oblique, longitudinal, dorso-ventral and vertical muscle fibres.

2. Botryoidal tissues is scattered within the body cavity.

3. A section of rectum is present in the centre and is lined by an epithelium of prismatic cells.

4. The crop diverticulum is seen on both the lateral sides of rectum.

6. Dorsal haemocoelomic channel, ventral haemocoelomic channel and lateral haemocoelomic channels enclosing the ventral nerve cord are present.

7. A section of posterior sucker, containing posterior sucker glands, lies below the rectal section.

UNIT 07: ARTHROPODA

7.1- Objectives

7.2- Identification, systematic position and general study of**:-**

Limulus, Spider, Palamnaeus, Apus, Lepas, Balanus, Sacculina, Palaemon, Lobster, Eupagurus Crab, Lepisma, Odontotermes, Pediculus, Schistocerca, Papilic, Bombyx, Xenopsylla, *Apis*, *Julus* and Scolopendra. Crustacean larvae (*Nauplius*, *Zoea*, *Megalopa* and *Mysis*), mosquito larva & pupa. *Sacculina*, Lice, flea, bedbug, tick and mites.

7.6-References

GENERAL CHARACTERS:-

1. Arthropoda (Gr., arthros+podos= jointed legs) includes insects, arachnids, myriapods, and crustaceans. are bilaterally symmetrical, triploblastic and metamerically segmented animals.
2. Body can be divided into head, thorax and abdomen; head and thorax are often fused to form Cephalothorax.
3. Exoskeleton made up of chitin secreted by epidermis.
4. Body is segmented and each segment bears a pair of jointed appendages.
5. Coelom largely a blood-filled haemocoel.
6. Muscles are mostly striated, usually capable of rapid contraction.
7. Digestive tract is complete. The mouth and anus lie at opposite ends of the body.
8. Circulatory system is open with tubular dorsal heart. Blood is colourless.
9. Respiration by general body surface, gills, tracheae or book lungs.
10. Nervous system has dorsal nerve ring.
11. Excretory organs are malpighian tubules (in insects) and green glands (in Crabs and prawn).
12. Sexes are generally separate. Sexual dimorphism is seen.
13. Fertilization is internal, oviparous and ovoviviparous.
14. Development is direct or indirect and may include a number of larval forms.
14. Parental care is well marked in many arthropods.

7.2 LIMULUS

Systematic position:

Phylum	Arthropoda
Class	Merostomata
Genus	*Limulus*

Comments:

1. *Limulus* (Fig. 1) is commonly known as king crab.
2. It is bilaterally symmetrical, triploblastic metamerically segmented animal with jointed appendages.
3. Body is divided into anterior prosoma, posterior opisthosoma and a spine like tail or telson.

4. Prosoma is covered by a horse-shoe shaped carapace. It bears a pair of simple eyes and a pair of compound eyes. It bears 6 pair of appendages surrounding the mouth. The first pair of chelicerae is small, trisegmented and chelate. Rest of the five appendages consists of four pairs are chelate legs and a last pair of non-chelate leg.

5. Opisthosoma is hexagonal and movably articulated with prosoma. It consists of 6-segmented mesosoma and 3-segmented metasoma. It bears six pairs of appendages, the first pair is fused and forms the genital operculum and the remaining five pairs of appendages are flap like and membranous and are used for respiration.

6. The telson is used to flip itself over if stuck upside down and to steer in the water.

7. Excretion takes place through coxal glands.

8. Sexes are separate. Fertilization is external.

Habit and habitat:

Limulus is marine form and found in shallow waters along sandy and muddy shores of sheltered bays and estuaries. It feeds on molluscs, annelid worms and other benthic invertebrates.

Distribution:

It is found along the eastern coast line of Asia, Gulf of Mexico and North America (Kotpal, 2005).

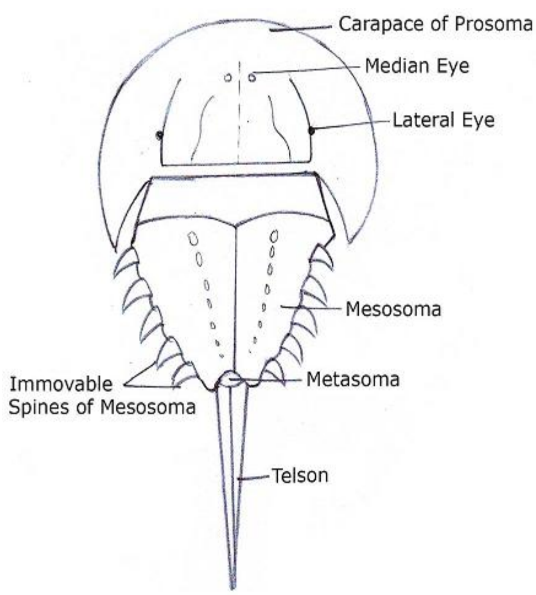


Fig. 1. *Limulus*

ARANEA:

Systematic position:

Phylum Arthropoda

Class Arachnida

Order Araneida

Genus *Aranea*

Comments:

1. *Aranea* (Fig. 2) is commonly known as orb-webbed spider.

2. Body can be divided into prosoma and opisthosoma connected by a cylindrical region called pedicel.

3. Prosoma is covered by carapace that bears 4 pairs of simple eyes. It bears 6 pair of appendages, a pair of chelicerae, a pair of pedipalps and 4 pair of walking legs. Chelicera is used to deliver venom to kill prey and is also used to capture and crush prey.

4. Opisthosoma is soft; egg shaped and houses the internal organs. It bears three pairs of spinneret or spinning organ which emit silk.

5. Respiration happens via book lungs or tracheae or both.

6. Excretion by malpighian tubules and coxal glands.

7. Sexes are separate.

8. Fertilization is internal but indirect. Usually the male die after mating, mostly killed by the female.

Habit and habitat:

Aranea is found in houses, gardens, under rocks, logs or the bark to trees. Most species are nocturnal and all are predatory.

Distribution:

They are found all over the world.

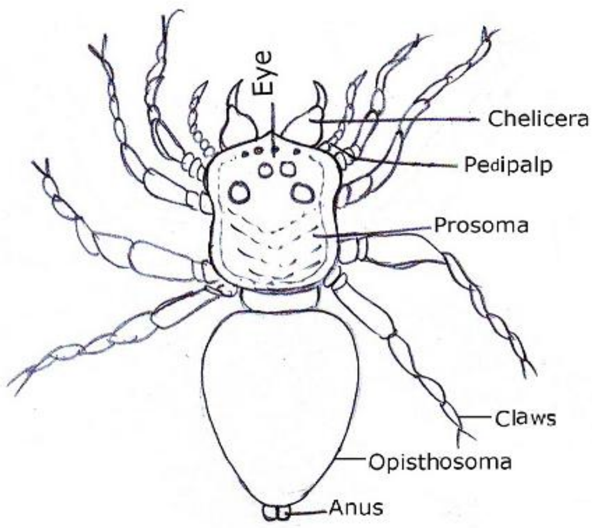


Fig. 2. *Aranea*

PALAMNAEUS

Systematic position:

Phylum Arthropoda

Class Arachnida

Order Scorpionidea

Genus *Palamnaeus*

Comments:

1. *Palamnaeus* (Fig. 3) is commonly known as scorpion.

2. Body is bilaterally symmetrical, triploblastic, coelomate, metamerically segmented animal with jointed appendages.

3. Body is differentiated into anterior prosoma, middle mesosoma and posterior metasoma.

4. Prosoma is covered by carapace that bears a pair of median eyes and 2-5 pairs of lateral eyes. It has six segments, each with a pair of appendages, *i.e*., one pair of chelicerae, one pair of pedipalp and four pairs of walking legs.

5. Opisthosoma consists of two parts anterior mesosoma and posterior metasoma.

6. Mesosoma is seven segmented, the first segment bears genital operculum, the second segment bears a pair of pectines and each of the third, fourth, fifth and sixth segments have a pair of stigmata. The seventh segment is without any appendages (Rastogi, 2015).

7. Metasoma is tail like and comprises five caudal segments and a last segment or telson bearing the sting.

8. Sexes are separate.

9. Viviparous.

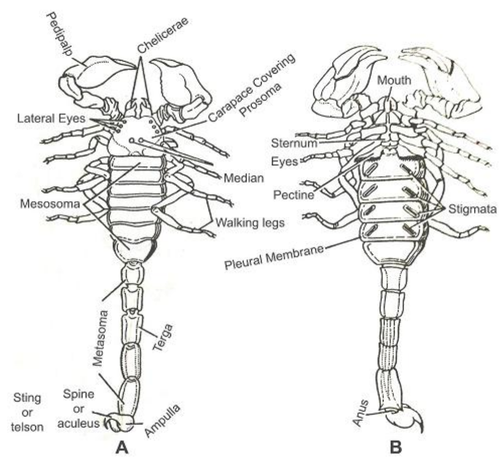
10. *Palamnaeus* are harmful to mankind; its sting can cause swelling at the sting site, extreme pain, fever and in some cases collapse.

Habit and habitat:

Palamnaeus is nocturnal, carnivorous and secretive animal. It is found in sand or under stones.

Distribution:

Palamnaeus are found on the land masses the world over except Antarctica.



A. Dorsal View B. Ventral View
Fig. 3. *Palamnaeus*

APUS

Systematic position:

Phylum	Arthropoda
Class	Crustacea
Order	Notostraca
Genus	*Apus*

Comments:

1. *Apus* (Fig. 4) is commonly called as tadpole fish or tadpole shrimp.

2. Body is elongated measuring about 20-30 mm in length.

3. Head is broad and depressed and contains a pair of eyes, a median eye and a dorsal organ above. Antennules and antennae are present below the head.

4. Horse-shoe shaped carapace, covering two-third of the anterior dorsal surface, bears shell glands on its lateral surface.

5. Anal segment bears a pair of caudal styles.

6. Sexes are separate.

7. Development includes nauplius larva.

Habit and habitat:

Apus is found in freshwater. It is omnivorous.

Distribution:

Apus is found in most parts of the world.

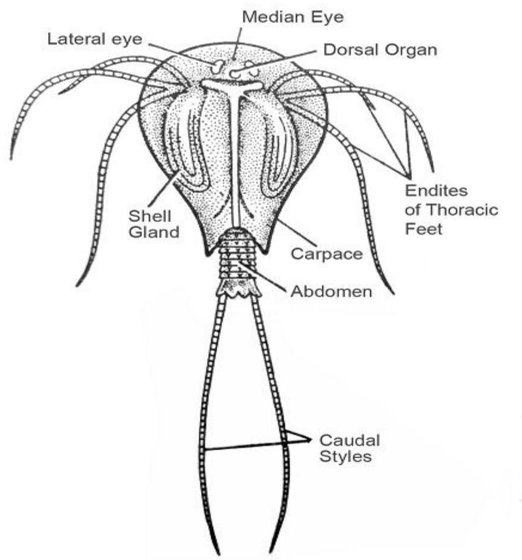


Fig. 4. Apus

LEPAS:

Systematic position:

Phylum Arthropoda

Class Crustacea

Order Thoracica

Genus *Lepas*

Comments:

1. *Lepas* (Fig. 5) is commonly known as ship or goose barnacle.
2. *Lepas* is bilaterally symmetrical, triploblastic metamerically segmented animal with jointed appendages.
3. The body is covered by a thick chitinous exoskeleton and by 5 calcareous plates-a pair of scuta, a pair of terga and a median dorsal carina.
4. The body or capitulum is supported by a long, flexible stalk called peduncle. It is found attached to ships and vegetation with the help of peduncle.
5. Mouth consists of a pair of mandibles and two pairs of maxillae.
6. Thorax bears six pairs of appendages.
7. It is bisexual.
8. Development includes a free-swimming cypris larva (Yadav and varshney, 2015).

Habit and habitat:

Lepas is a marine animal that inhabits warmer seas. They feed upon minute organisms gathered from water and kicked into mouth by the thread like feet.

Distribution:

Lepas is found all over the world.

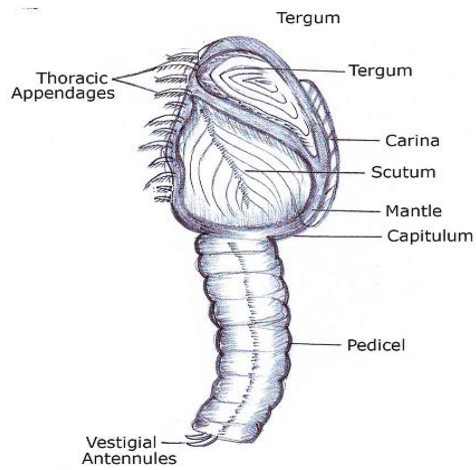


Fig. 5. *Lepas*

BALANUS

Systematic position:

Phylum	Arthropoda
Class	Crustacea
Order	Thoracica
Genus	*Balanus*

Comments:

1. *Balanus* (Fig. 6) is commonly called as rock barnacle or acorn barnacle.

2. Body is bilaterally symmetrical, triploblastic metamerically segmented animal with jointed appendages.

3. Body is surrounded by a calcareous shell consisting of six plates: an unpaired rostrum, an unpaired carina and two pairs of carino-lateral plates.

4. A four-fold cover, consisting of two scuta and two terga covers the shell opening.

5. Six pairs of thoracic legs are provided that can protrude out of the shell opening to collect food particles.

6. Hermaphrodite. Development is indirect involving a nauplius larva.

Habit and habitat:

Balanus is found attached to rocks and molluscan shells.

Distribution:

Balanus is cosmopolitan in distribution. It is mainly found along North Atlantic coast, Pacific coast, West Indies and Washington to Alaska.

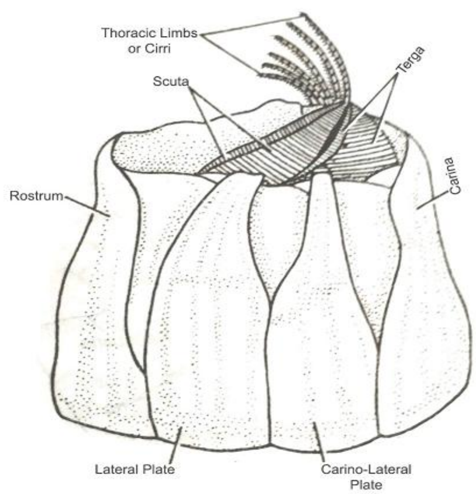


Fig. 6. *Balanus*

SACCULINA

Systematic position:

Phylum Arthropoda

Class Crustacea

Order Rhizocephala

Genus *Sacculina*

Comments:

1. *Sacculina* (Fig. 7) is commonly known as root-headed barnacle.

2. It lives as a parasite on crab's abdomen.

3. The body is made up of two parts- a thin sac and a peduncle. The sac appears like a fleshy tumour attached to the abdomen by a peduncle. The peduncle consists of numerous root-like filaments which protrude body of the host to derive nutrition.

4. Appendages, segmentation, alimentary canal and anus are absent.

5. Hermaphrodite, *i. e.* sexes united.

6. Larva is cirripede-nauplius.

7. The female *Sacculina*, attached to male crab, causes hormonal imbalance in the crab that makes it infertile (parasitic castration).

Habit and habitat:

Sacculina live in marine environment.

Distribution:

Sacculina is cosmopolitan.

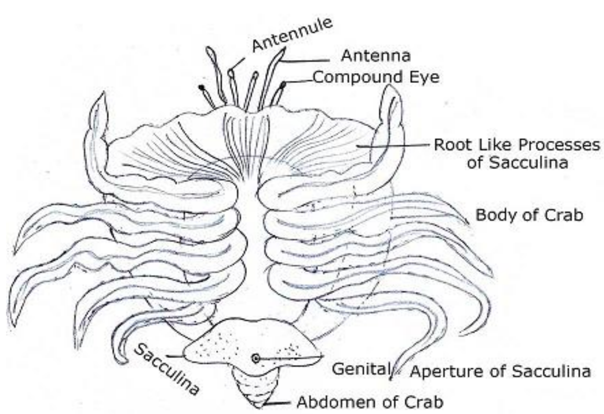


Fig. 7. Sacculina

PALAEMON

Systematic position:

Phylum	Arthropoda
Class	Crustacea
Order	Decapoda
Genus	*Palaemon*

Comments:

1. *Palaemon* (Fig. 8) is commonly known as prawn.

2. Body is elongated, spindle shaped and bilaterally symmetrical.

3. *Palaemon* species are of pale-yellow, pale-blue and greenish color with brown tinge or with orange-red patches. Preserved specimens become deep orange-red.

4. The body can be divided into two regions, anterior cephalothorax and posterior abdomen.

5. Cephalothorax is a large, rigid, unjoited, **immovable and cylindrical structure. It consists of 13 segments, 5 of the head region, and 8** of the thorax region (Kotpal, 2005).

6. Abdomen is rounded, jointed and compressed laterally. It consists of 6 movable segments and a terminal conical structure, called telson. Each abdominal segment bears a pair of jointed appendages called pleopods or swimmerets.

7. The prawn uses its walking legs for movement at the water-bed.

8. Respiration happens *via* gills, epipodites and lining of branchiostegites.

9. Excretion through a pair of antennary or green glands, a pair of lateral ducts, an unpaired renal or nephroperitoneal sac and the integeument.

10. Sexes are separate. Sexual dimorphism is well developed.

Habit and habitat:

Palaemon is found in freshwater ponds, lakes, streams, ditches and rivers. It is a nocturnal creature. It hides at the bottom during the day and comes to the surface at night in search of food. It feeds mainly on algae, moss and other aquatic weeds.

Distribution:

Palaemon is commonly found in India.

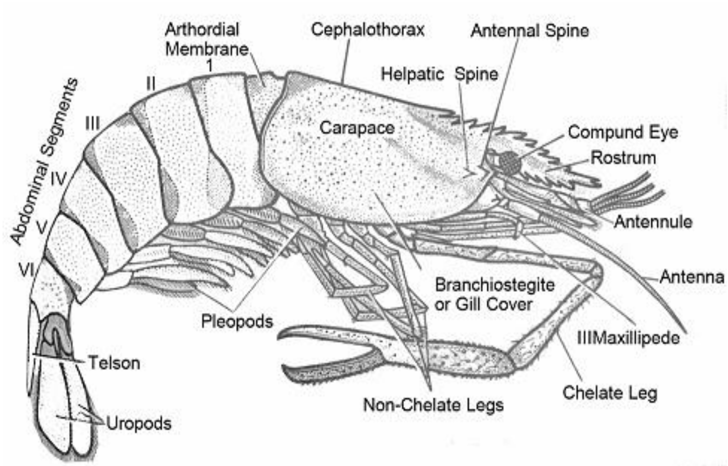


Fig. 8. Palaemon

PALINURUS: LOBSTER:

Systematic position

Phylum	Arthropoda
Class	Crustacea
Order	Decapoda
Genus	*Palinurus*

Comments:

1. *Palinurus* (Fig. 9) is commonly called spiny lobster.

2. Body is covered with spines and is greenish brown in colour.

3. Size ranges from 15 to 45 cm.

4. The Body is divided into cephalothorax and abdomen.

5. The cephalothorax consists of the head having five segmentes and the thorax having eight segments.

6. The abdomen consists of six segments and a telson.

7. Each body segment bears a pair of appendages on its ventral side.

7. Sexes are separate

8. Development includes phyllosoma larva.

Habit and habitat:

Palinurus is a marine, bottom-dwelling crustacean. This is an omnivorous animal feeding on worms, molluscs, corals, algae etc.

Distribution:

Palinurus occurs in Asia, Europe and India.

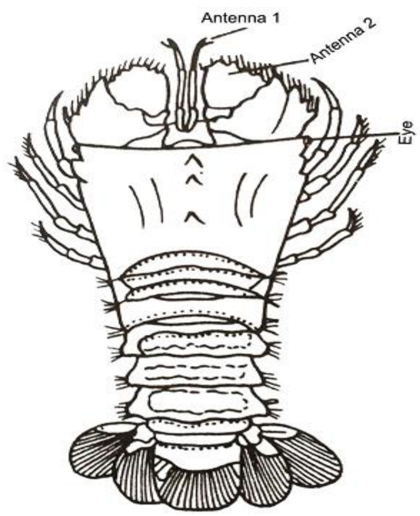


Fig. 9. Palinurus

EUPAGURUS

Systematic position

Phylum	Arthropoda
Class	Crustacea
Order	Decapoda
Genus	*Eupagurus*

Comments:

1. *Eupagurus* (Fig. 10) is commonly known as hermit crab.

2. Body is asymmetrical, elongated and divisible into cephalothorax and abdomen.

3. Body is extremely modified in order to live inside the molluscan shells.

4. Cephalothorax is broad and flattened.

5. Head bears a pair of compound eyes, a pair of large antennae and a pair of short antennules. Thorax bears five pair of legs. First, fourth and fifth pair of legs are chelate whereas rest of the legs are non chelate. Front two legs are of different sizes the large left claw is used for defense purpose and the smaller right claw is used for scooping food and water (Verma, 2015).

6. Abdomen is soft and is spirally twisted.

7. Abdominal appendages of the left side are reduced while those of the right side are absent (Fig. 10).

Habit and habitat:

Eupagurus inhabits the abandoned shells of gastropods. It is a nocturnal creature, generally silent during the day. It leads a commensal life.

Distribution:

Eupagurus is cosmopolitan. It is found at Bombay and Goa beaches, from Alaska to Lower California and Florida.

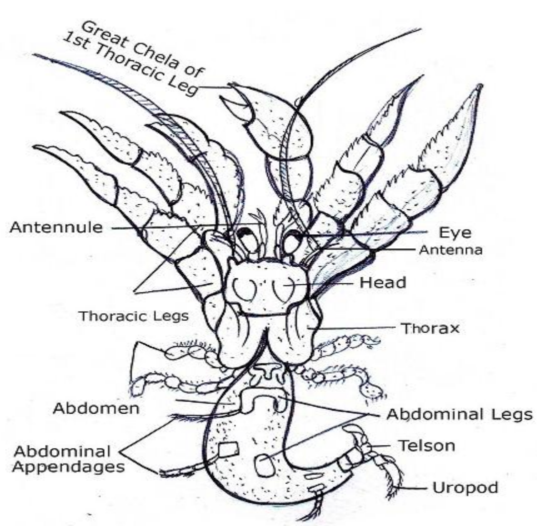


Fig. 10. *Eupagurus*

CARCINUS

Systematic position

Phylum	Arthropoda
Class	Crustacea
Order	Decapoda
Genus	*Carcinus*

Comments:

1. *Carcinus* (Fig. 11) is commonly called rock crab or true crab.

2. Body is dorso-ventrally compressed and consists of a cephalothorax and an abdomen.

3. Cephalothorax is enlarged and is convered by a broad flat shell called carapace. It bears a pair of small antennules, a pair of longer antennae, five pairs of thoracic legs and a pair of compound eyes. The first pair of thoracic legs has claws (Rastogi, 2015).

4. Mouth parts present on the ventral surface are covered by the flat, plate-like third maxillipedes.

5. Abdomen is greatly reduced and it bears pleopods. Uropods are absent.

6. The abdomen of the female is wider than that of the male. Female has four pairs of pleopods that help in carrying eggs. Male has two pairs of pleopods that act as copulatory organs.

7. Development is indirect through zoea and megalopa larval stages.

Habit and habitat:

Carcinus is found buried in mud of shallow waters or buries itself amongst rocks. It typically walks sideways. It is mostly omnivorous feeding on algae, molluscs, worms, fungi, bacteria etc.

Distribution:

Carcinus is cosmopolitan in distribution.

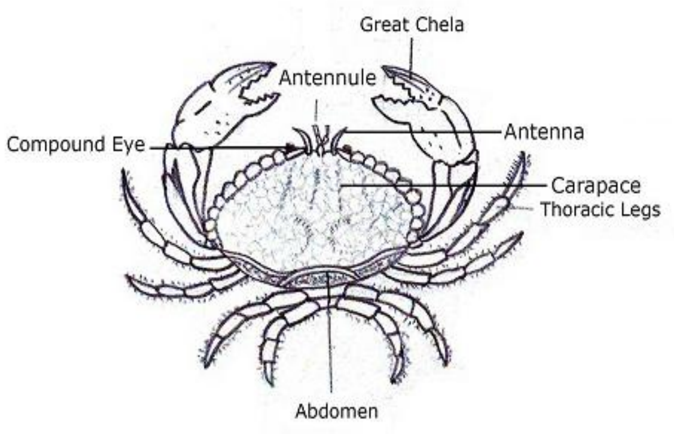


Fig. 11. *Carcinus*

LEPISMA

Systematic position

Phylum	Arthropoda
Class	Insecta
Order	Thysanura
Genus	*Lepisma*

Comments:

1. *Lepisma* (Fig. 12) is a primitive wingless insect commonly known as silver fish.

2. It is triploblastic, bilaterally symmetrical, metamerically segmented animal with jointed appendages.

3. Body is covered with silvery scales and is divided into head, thorax and abdomen.

5. Head bears a pair of long, jointed antennae and a pair of eyes.

6. Thorax bears three pairs of legs.

7. Abdomen eleven segmented with a pair of long anal cerci and a median caudal filament.

8. Mouth parts are biting and chewing type.

9. Silver fish consume matter that contains polysaccharides such as starch used in adhesives. It causes considerable damage to the books and clothing by chewing off starch, sizing or any other articles containing glue.

10. Development direct without metamorphosis.

Habit and habitat:

Lepisma is household pest and a nocturnal insect. It is commonly found in cool places, damp, books and clothes.

Distribution:

Lepisma is cosmopolitan in distribution. It is found in Africa, America, Europe, Asia and Australia.

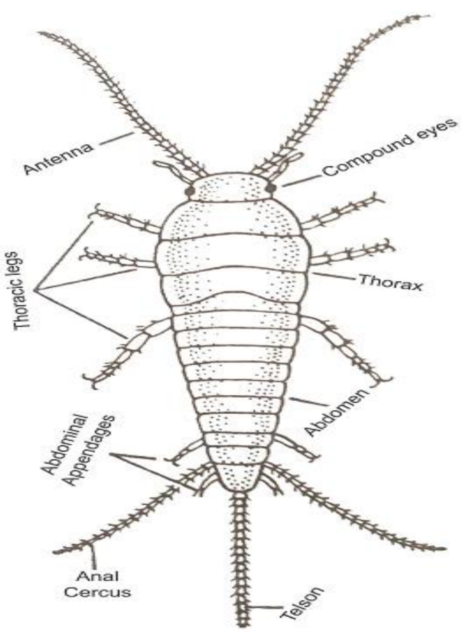


Fig. 12. *Lepisma*

ODONTOTERMES

Systematic position

Phylum Arthropoda

Class Insecta

Order Isoptera

Genus *Odontotermes*

Comments:

1. *Odontotermes* (Fig. 13) is commonly called as termite.

2. Body is soft, elongated and cylindrical and has three distinct regions: head, thorax and abdomen.

3. Head and thorax are small as compare to abdomen.

4. Head bears a pair of compound eyes, a pair of antennae and the mouth.

5. Thorax bears three pairs of walking legs.

5. Abdomen bears of ten segments. The ninth segment bears a pair of anal cerci. It is swollen to accommodate the large number of fertilized eggs.

6. Mouth parts are biting type.

6. Social and polymorphic insects. They live together in large communities.

7. Colony consists sexually mature males and females (kings and queens), sterile workers, soldiers and nasutes.

8. Wings are well developed.

9. Termites are known to cause huge economic loss they damage the household furniture and other materials made up of wood.

Habit and habitat:

Termite is nocturnal, and lives in tunnels constructed inside wood and earth. Some termites make huge mounds using excavated mud, wood and excreta mixed with saliva. They feed upon vegetation, wood, faecal matter of termites and the dead of the colony (Wikipedia).

Distribution:

Termites are found all over the world.

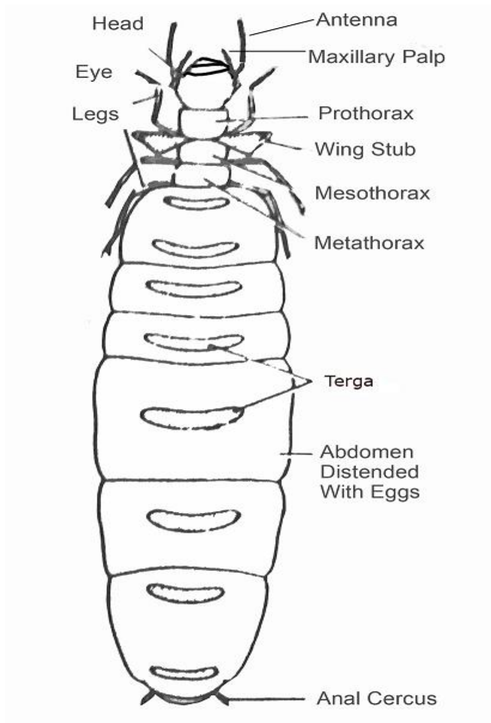


Fig. 13. *Odontotermes*

PEDICULUS

Systematic position

Phylum Arthropoda

Class Insecta

Order Anoplura

Genus *Pediculus*

Comments:

1. *Pediculus* (Fig. 14) is commonly called human louse.

2. Body is dorso-ventrally flattened and consists of head, thorax and abdomen.

3. Head is small and bears a pair of five segmented antennae, a pair of compound eyes and mouth.

4. Thorax bears three pairs of legs having claws.

5. Abdomen is large and consists of nine segments.

6. Mouth parts are piercing and sucking type.

7. The last abdominal segment of male is pointed and that of female is bilobed.

Habit and habitat:

Pediculus humanus is found as an ectoparasite of man.

Distribution:

Pediculus humanus has worldwide distribution.

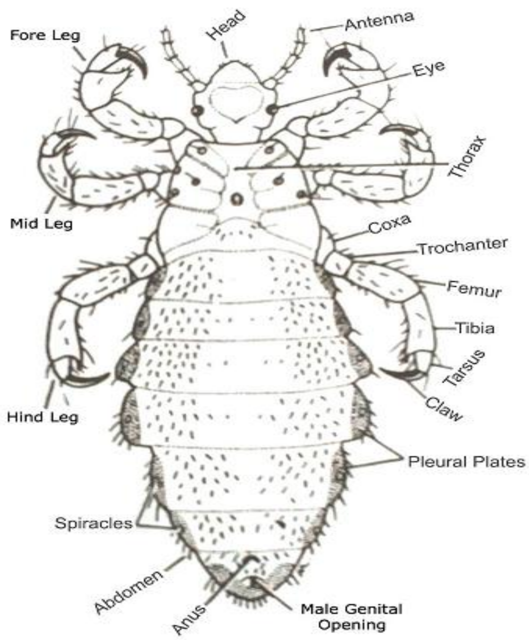


Fig. 14. *Pediculus*

SCHISTOCERCA

Systematic position

Phylum	Arthropoda
Class	Insecta
Order	Orthoptera
Genus	*Schistocerca*

Comments:

1. *Schistocerca gregaria* (Fig. 15) is commonly called as locust.

2. Body is divisible into head, thorax and abdomen.

3. Head bears a pair of joint antennae or feelers, a pair of large compound eyes, jointed appendages called palps and mouth.

4. Mouth parts are biting and chewing type.

5. Thorax bears two pairs of wings and three pairs of legs. The hind legs are large and used for jumping

6. Fore-wings are hard and thick, while hind-wings are larege, membranous.

7. Abdomen consists ten segments with eleventh vestigial segment.

8. This locust is most destructive to crops and vegetarian.

9. Sexes are separate. The males have a boat shaped tip of the abdomen while females have two valves on the tip of the abdomen.

Habit and habitat:

Schistocerca gregaria is found in the deserts and in tropical region of the world.

Distribution:

Schistocerca gregaria is worldwide distribution.

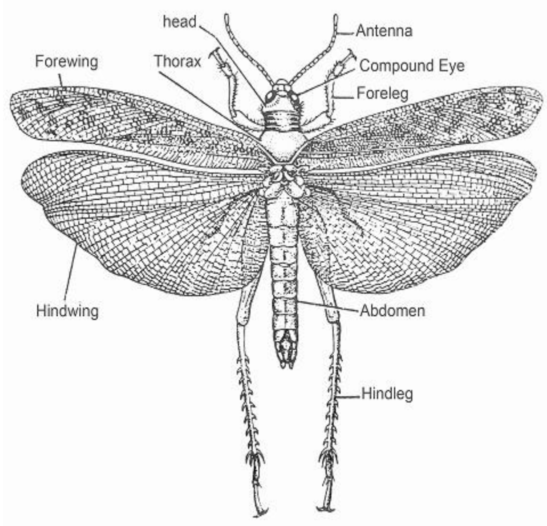


Fig. 15. *Schistocerca*

PAPILIO

Systematic position

Phylum Arthropoda

Class Insecta

Order Lepidoptera

Genus *Papilio*

Comments:

1. *Papilio* (Fig. 16) is commonly known as butterfly.

2. Body consists of head, thorax and abdomen.

3. Head bears a pair of compound eyes and a pair of long antennae with swollen rounded ends and mouth (Yadav and Varshney, 2015).

4. Mouth parts are of siphoning type.

5. Thorax bears three pairs of legs and two pairs of wings that are covered with broad pigmented scales.

7. Abdomen is composed of ten segments and is covered with scales.

8. Development includes caterpillar larva.

9. Butterflies are nectarivores and feed from nectar of flowers.

Habit and habitat:

Butterflies are common insects that are seen in gardens. They are diurnal.

Distribution:

Butterflies are cosmopolitan in distribution.

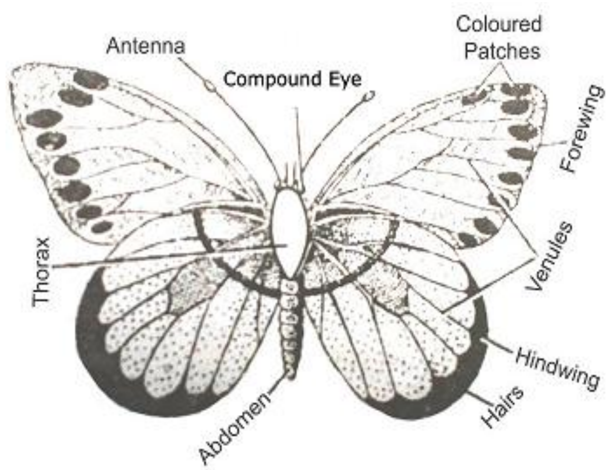


Fig. 16. *Papilio*

BOMBYX

Systematic position

Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Genus	*Bombyx*

Comments:

1. *Bombyx* (Fig. 17) is commonly called as silk moth.

2. Body consists of head, thorax and abdomen.

3. Head bears a pair of plumed antennae and a pair of compound eyes.

4. Thorax bears three pairs of legs and two pairs of wings which are covered with scales.

5. Hindwing is smaller than forewing.

6. The abdomen is consists of ten segments.

7. Mouthparts are siphoning type.

8. Moths are nocturnal. They come on the light during the rainy season.

Habit and habitat:

Bombyx is reared for silk. The adults have a short lifespan and don not feed.

Distribution:

Bombyx are cosmopolitan in distribution.

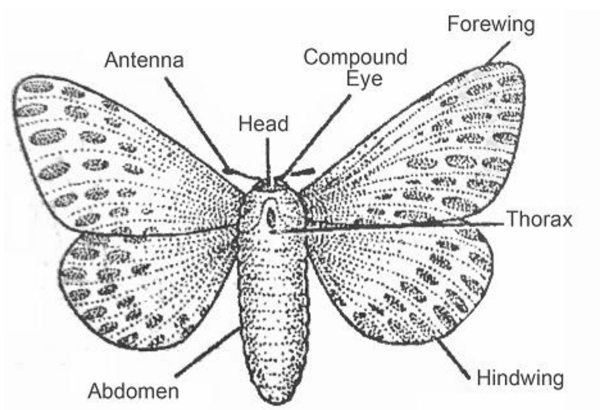


Fig. 17. Bombyx

XENOPSYLLA

Systematic position.

Phylum	Arthropoda
Class	Insecta
Order	Siphonoptera
Genus	*Xenopsylla*
Species	*cheopis*

Comments:

1. *Xenopsylla cheopis* (Fig. 18) is commonly known as rat flea.
2. Body is divisible into three segments: head, thorax and abdomen.

3. Body is laterally compressed without wings and covered with hard plates called sclerites.

4. Integument is heavily sclerotized, brown in clour and armed with backwardly directed spines and bristles.

5. Head contains simple eyes, antennae and mouth. The mouth parts are piercing and sucking type.

6. Thorax is compact with segmention and has three pairs of legs. The hind legs are longest and strongest and help in jumping.

10. Abdomen is ten segmented.

11. The adult flea is active and slips through hair with great ease.

Habit and habitat:

Xenopsylla cheopis is an ectoparasite of mammals specially rats. It feeds on blood. It is known to transmit plague from rats to man.

Distribution:

Xenopsylla cheopis is found in India, Sri Lanka, Myanmar and Malaysia.

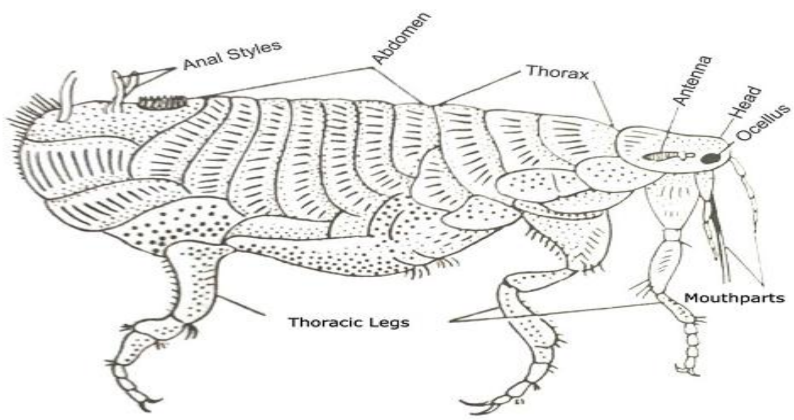


Fig. 18. Xenopsylla

APIS

Systematic position

Phylum	Arthropoda
Class	Insecta
Order	Hymenoptera
Genus	*Apis*

Comments:

1. *Apis* (Fig. 19) is commonly known as honey bee.

2. *Apis* is a social insect and lives in a highly organized petennial colony in bee hive.

3. The body is divided into three distinct regions; head, thorax and abdomen.

4. Head contains mouth, compound eyes and a pair of antennae. Mouth parts are chewing and lapping type.

5. Thorax contains three pairs of legs and two pairs of wings.

6. Abdomen is segmented and contains spiracles for breathing.

7. Honey bee colony consists of a queen, male drones and sterile female workers.

8. Female worker bees have the ovipositor modified to form sting.

9. Female worker bees do duties like - food collection, bringing nectar, making wax cells, looking after the young ones, building and cleaning the hive, etc.

10. The queen is larger in size than workers and drones. It has a longer abdomen and its duty is to lay eggs only.

11. The drones are the male members of the colony, without stings. They mate with queen and die after mating.

12. The honey bees are economically important insects as they are the source of honey and bees wax.

13. Bee keeping is called apiculture.

Habit and habitat:

Apis lives in colonies of couple of thousands bees. A colony consists of a single egg laying female or queen, several hundred male drones and thousand of sterile female workers. The worker bees collect nectar from the nectaries of flowers (Wikipedia).

Distribution:

Cosmopolitan. Honeybee is commonly found in India, Europe and Africa.

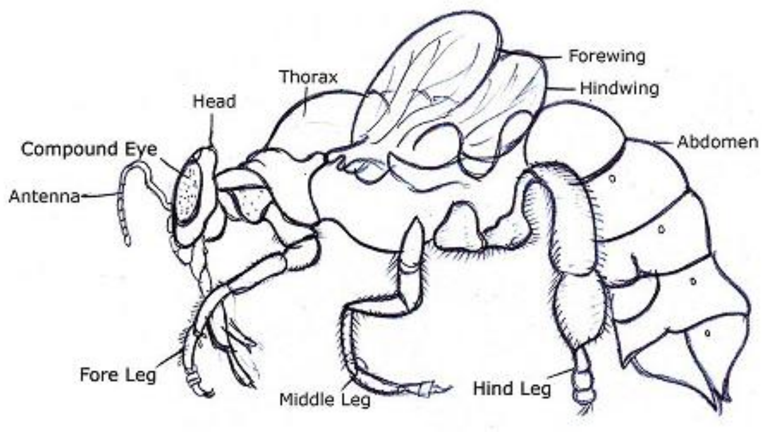


Fig. 19. *Apis*

JULUS

Systematic position

Phylum	Arthropoda
Class	Myriapoda
Order	Diplopoda
Genus	*Julus*

Comments:

1. *Julus* (Fig. 20) is commonly called millipede or wire worm.

2. Body is elongated, cylindrical and consists of a large number of segments.

3. Body is divided into head, thorax and abdomen.

4. Head contais a pair of large mandibles, eyes and a pair of antennae having seven joints.

5. Thoracic segments each having a pair of legs, while abdominal segments bear two pairs of legs each.

6. Microscopic holes called ozopores (Stink glands) present along the sides of the body, secreting noxious substance as a defence mechanism.

7. Sexes are separate.

Habit and habitat:

Julus is found hidden usually in dark and damp places under stones or wood or in decaying leaves. It feeds on decomposing vegetation faeces and organic matter mixed with soil.

Distribution:

Julus is cosmopolitan in distribution; found in India, Europe and U.S.A.

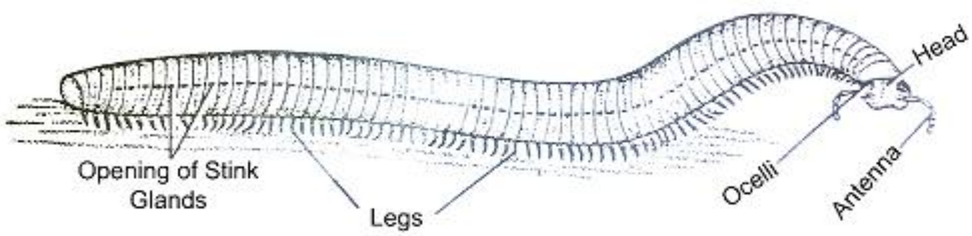


Fig. 20 *Julus*

SCOLOPENDRA

Systematic position

Phylum Arthropoda

Class Myriapoda

Order Chilopoda

Genus *Scolopendra*

Comments:

1. *Scolopendra* (Fig. 21) is commonly known as centipede.

2. Body is elongated and dorsoventrally flattened with numerous segments.

3. Body is divided into small head and a long trunk.

4. Head bears a pair of antennae, eyes, a pair of mandibles and two pairs of maxillae.

5. Trunk has 22 identical segments each (except first) has a pair of walking legs.

6. First pair of trunk appendages or maxillipedes bears a sharp claw through which opens the poison gland (Verma, 2005).

7. Sexes are separate.

8. It is nocturnal and mostly carnivorous.

9. *Scolopendra* is harmful to mankind because of their venomous bite.

Habit and habitat:

Scolopendra commonly occurs under stones, in rotten logs and in houses in damp places.

Distribution:

Scolopendra is found in India and U.S.A.

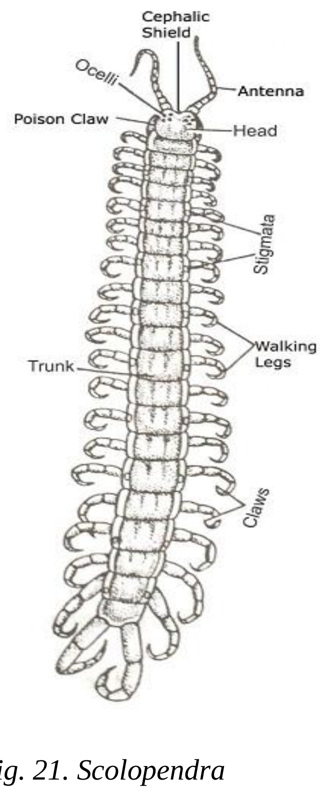


Fig. 21. Scolopendra

APHID

Systematic position:

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Genus	*Aphid*

Comments:

1. *Aphid* (Fig. 22) is commonly known as plant lice.

2. Body is soft, short and pear-shaped and is divided into head, thorax and abdomen.

3. Head is quite distinct, bears large antennae and well developed compound eyes.

4. Mouth parts are piercing and sucking type.

5. Thorax bears three segments each having a pair of legs.

6. Abdomen consists of eight segments. Nine pairs of lateral abdominal spiracles are present.

7. Aphids are sometime winged or wingless.

8. It is viviparous.

9. They show the phenomena of parthenogenesis.

Habit and habitat:

Aphid is found on plants and sucks their juice. Some of the species are monophagous.

Distribution:

Aphid is distributed throughout the world.

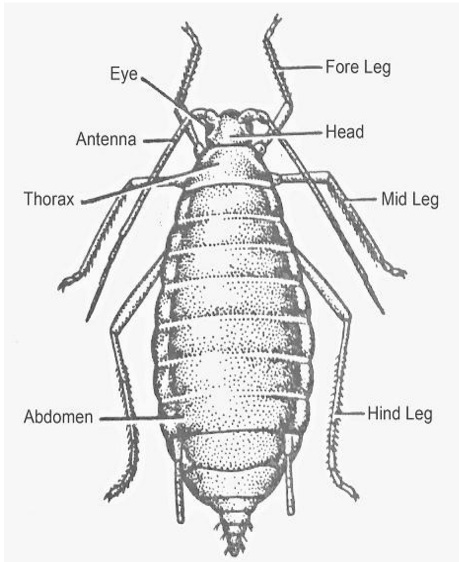


Fig. 22. *Aphid*

CIMEX

Systematic position:

Phylum	Arthropoda
Class	Insecta
Order	Hemiptera
Genus	*Cimex*

Comments:

1. *Cimex* (Fig. 23) is commonly known as bed bug.

2. Body is dorso-ventrally flattened and oval, measuring 5 mm in length.

3. Body comprises of head, thorax and abdomen.

4. Head is short and broad and bears a pair of compound eyes, a pair of antennae and proboscis.

5. Mouth parts are piercing and sucking type.

6. Thorax is divisible into a prothorax, mesothorax and a metathorax. It bears three pairs of legs.

7. Wings are absent.

8. Abdomen is large and bears seven segments. In male has a pointed tip abdomen while female has a curved abdominal end.

9. Sexes are separate.

10. Its bite causes skin rashes and allergy in humans.

Habit and habitat:

Cimex is found inhabiting beds, or other places where peoples sleep. It is also found in luggage, backpacks, clothing, electronic items and furnitures. It is nocturnal. It is hematophagous and sucks human blood.

Distribution:

Cimex is widely distributed all over the world.

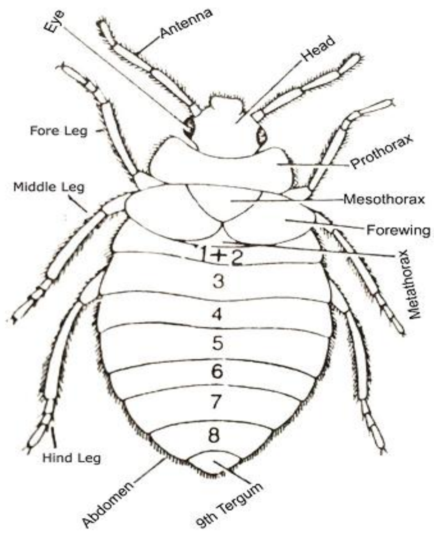


Fig. 23. *Cimex*

IXODES

Systematic position:

Phylum Arthropoda

Class Arachnida

Order Acarina

Genus *Ixodes*

Comments:

1. *Ixodes* (Fig. 24) is commonly called sheep tick.

2. It is small compressed leathery body with no sign of segmentation.

3. Head, Thorax and abdomen are fused into a single body segment.

4. Mouthparts have a pair of palps, a pair of chelicerae and a barbed, needle like hypostome. Mouth parts are piercing and sucking.

5. In males scutum covers entire dorsal surface while in female it is smaller.

6. Four pairs of slender legs. Behind the fourth pair of legs is a pair of prominent spiracles leading into convoluted tracheae. Respiration happens via spiracles and tracheae.

7. Genital aperture is situated in approximate midline between the coxae.

8. Anus is situated on the posterior ventral side.

9. Female is larger than male.

10. Ixodes can cause anaemia, fever, dermatosis in sheep and other domestic animals.

Habit and habitat:

Ixodes is an ectoparasite, found on the body of sheep. It typically lives on the surface of warm blooded animals and feed on their blood.

Distribution:

Ixodes is commonly found in worldwide, especially in warm and humid areas.

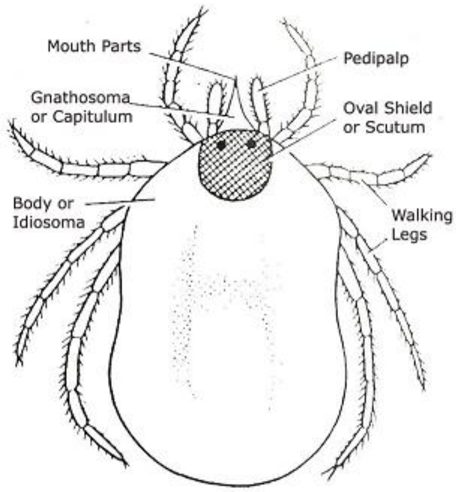


Fig. 24. *Ixodes*

SARCOPTES

Systematic position:

Phylum Arthropoda

Class Arachnida

Order Acarina

Genus *Sarcoptes*

Comments:

1. *Sarcoptes* (Fig. 25) is commonly known as mite.

2. Body is rounded and dorso-ventrally flattened.

3. No external division into head, thorax and abdomen.

4. The body is covered with spines which are sensory in function.

5. Eyes and trachea are absent.

6. The mouth parts produce a head-like structure, the gnathosoma that bears a pair of chelicerae and a pair of pedipalpi.

7. Legs are short and stumpy. Four pairs of legs, the two anterior pairs are stronger and have terminal stalked suckers while the two posterior pairs are shorter and attached more ventrally and carry long bristles.

Habit and habitat:

Sarcoptes scabiei is a human ectoparasite which causes scabies or itching. Repeated infection of itching turns into eczema. It burrows into the skin and often spend entire life cycle within that burrow.

Distribution:

Sarcoptes is cosmopolitan in distribution.

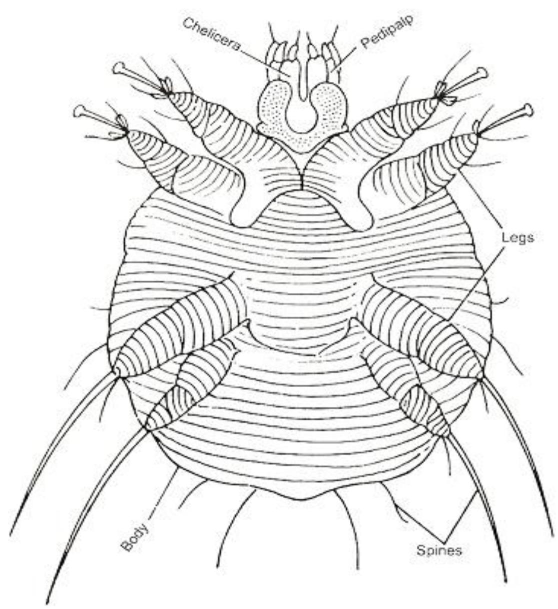


Fig. 25. *Sarcoptes*

NAUPLIUS LARVA

Comments:

1. Nauplius larva (Fig. 26) is the first larval stage of many crustaceans.

2. Body is unsegmented and oval in shape. It has a broad anterior head region, middle trunk region and bilobed anal region.

4. Head bears a single median eye and a pair of antennules.

5. Trunk bears a pair of antennae and a pair of mandibles. These two pairs are biramous and are used for swimming.

6. Mouth opens at the anterior end, while anus lies on the posterior extremity.

7. Nauplius larva goes through a number of intermediate stages before it reaches the adult stage. Each such stage is separated by a moult in which the larva sheds hard exoskeleton to allow the animal to grow.

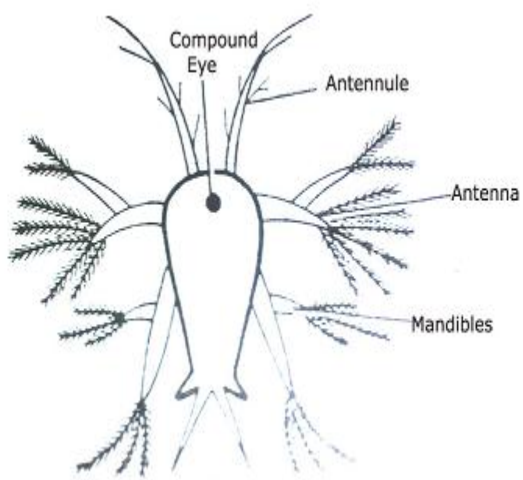


Fig. 26. Nauplius larva

ZOEA LARVA

Comments:

1. Zoea larva (Fig. 27) is a larval stage of the crustaceans.

2. Body consists of an unsegmented cephalothorax and segmented abdomen.

3. Cephalothorax is covered by a carapace and has a pair of compound eyes.

4. Head contains one dorsal, one rostrum and two lateral spines.

5. It contains mandibles, maxillae, antennules, antennae and two pairs of well developed maxillipedes.

6. Six pairs of thoracic appendages develop as buds. It uses thoracic appendages for swimming.

7. Abdomen comprises of six segments and bears caudal fork.

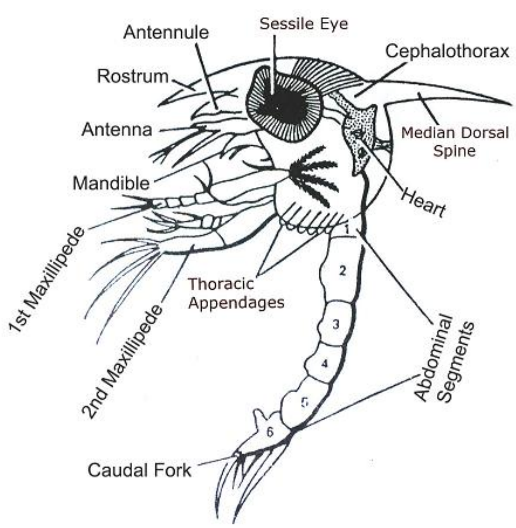


Fig. 27. Zoea larva

MEGALOPA LARVA

Comments:

1. Megalopa larva (Fig. 28) is the larva of crab and it develops from zoea larva.

2. It has a large, broad and crab-like unsegmented cephalothorax bearing a median spine.

3. It has a pair of large and stalked eyes.

4. Antennae are large while antennules are small.

5. Thoracic appendages are well developed.

6. Abdomen has six segments bearing biramous pleopods and a telson. Pleopods are used for swimming.

7. Megalopa leads a pelagic life for some time and later on sinks down to the bottom and moults into adult.

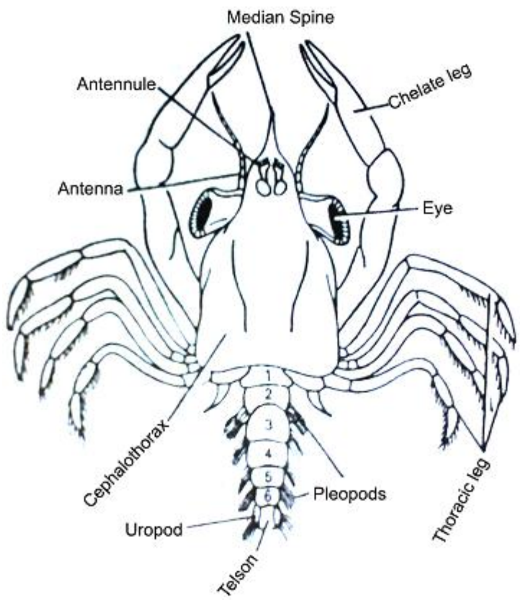


Fig. 28. Megalopa larva

MYSIS LARVA

Comments:

1. Mysis (Fig. 29) is a stage in Arthropoda such as *Peanaeus*.

2. The body appears similar to the adult *Mysis*.

3. Body is divisible into cephalothorax and abdomen.

4. Cephalothorax bears a pair of compound eyes, a rostrum, a pair of antennules and a pair of antennae.

6. It bears seven pairs of biramous thoracic appendages and used for locomotion.

7. Abdomen bears five pairs of biramous pleopods. The last abdominal segment has a telson and a pair of uropods.

8. Mysis larva metamorphoses into the adult prawn.

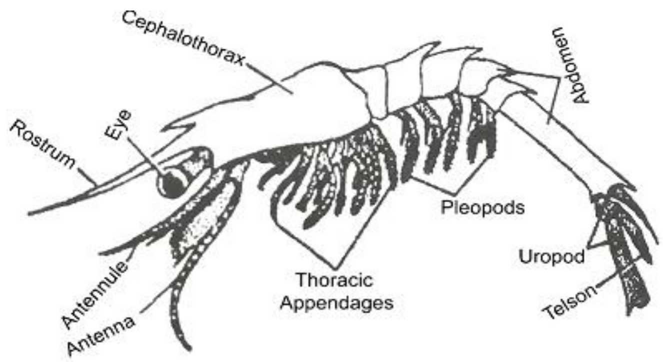


Fig. 29. Mysis larva

LARVA OF CULEX

Comments:

1. Culex larva (Fig. 30) appears out of eggs that hatch out in two or three days.

2. Body of larva is elongated and transparent. It is divided into head, thorax and abdomen.

3. Head is rounded and bears mouth parts, a pair of compound eyes and a pair of antennae.

4. Single rounded thoracic segment bears three pairs of lateral tufts of hairs.

5. Abdomen consists of nine segments each having a few bristles or hairs.

6. Eighth abdominal segment contains respiratory siphon with two spiracles.

7. Last abdominal segment bears tracheal gills and tufts of hairs.

8. Culex larva hangs with head downwards at an angle with the surface of water.

9. Larva feeds on microorganisms and organic matter.

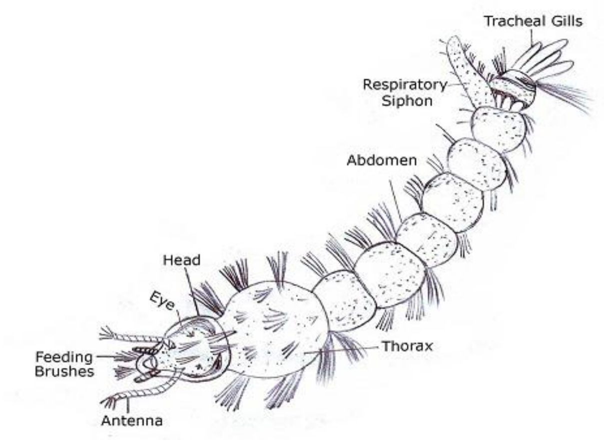


Fig. 30. Larva of Culex

LARVA OF ANOPHELES

Comments:

1. Culex larva (Fig. 31) appears out of eggs that hatch out in twenty four to forty eight hours.

2. Body of larva is divisible into head, thorax and abdomen.

3. Head is long and contains a pair of eyes, a pair of antennae and feeding brushes.

4. Thorax broad unsegmented and is provided with tufts of hairs.

5. Abdomen consists of nine segments and each has palmate hairs.

6. Respiratory siphon is absent. Eighth segment has a raised chitinous quadrilateral plate with two spiracles.

7. Last segment of abdomen bears tracheal gills for respiration.

8. Anopheles larva lies horizontally with head parallel to the water surface (Verma, 2015).

9. Larva feeds on algae, bacteria and other microorganisms.

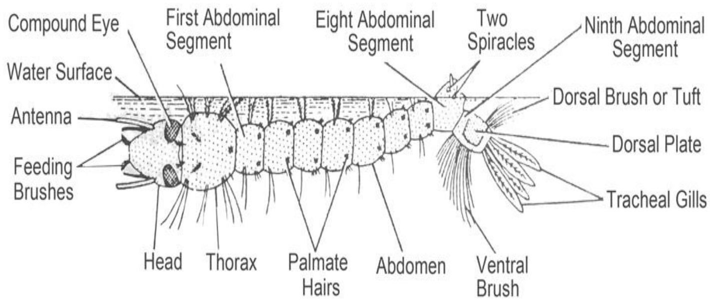


Fig. 31. Larva of Anopheles

PUPA OF CULEX

Comments:

1. Culex larva (Fig. 32) moults four times to change into pupa.

2. Body is comma-shaped and comprises of cephalothorax and abdomen.

3. Cephalothorax bears a pair of long and narrow respiratory trumpets on its dorsal surface.

4. Abdomen consists nine segments provided with tufts of bristles.

5. Last abdominal segment contains two chitinous leaf-like paddles used for swimming.

6. It does not feed and has occasional tumbling movement in water.

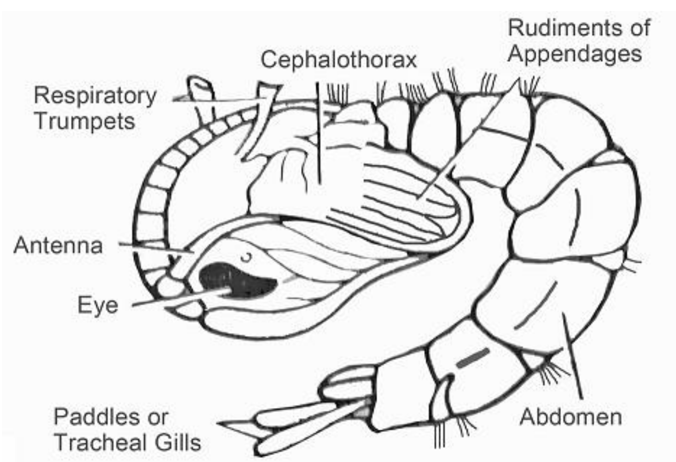


Fig. 32. Pupa of Culex

PUPA OF ANOPHELES

Comments:

1. Anopheles larva (Fig. 33) moults four times to become pupa.

2. Body of pupa comprises of cephalothorax and abdomen.

3. Cephalothorax bears a pair of short and broad respiratory trumpets with a terminal opening (Wikipedia).

4. Abdomen consists of nine segments and is more strongly curved than in Culex.

5. Eighth abdominal segment bears two paddles for swimming.

6. It does not feed and has occasional tumbling movement in water.

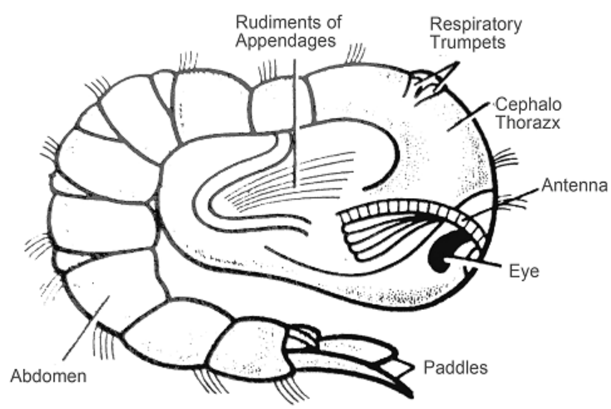


Fig. 33. Pupa of Anopheles

LONG ANSWER TYPE QUESTIONS:-

1. Classify Arthropoda up to orders giving their characters and examples.

2. Write short notes on: (1) *Palaemon* (2) *Sacculina* (3) *Scolopendra* (4) *Lepisma* (5) Termite

3. Describe various types of mouth parts in insects.

4. Write an essay on economical importance of insects.

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UNIT 8: PHYLUM MOLLUSCA

General characters:-

1. Molluscs are soft bodied, essentially aquatic, mostly marine, few freshwater and some terrestrial animals.

2. Body is soft, bilaterally symmetrical, unsegmented and without jointed appendages and can be divided into head, mantle, visceral mass and foot.

3. The head carries mouth, eyes and tentacles.

4. The mantle is a thick, muscular fold of body wall extended over the viscera and the enclosed space is called as the mantle cavity.

5. Visceral mass contains the visceral organs of the body in a compact form.

6. The foot is ventral in position and is usually thick and muscular being variously modified for creeping, ploughing and seizing.

7. Body cavity is haemocoel. The true coelom is generally limited to the pericardial cavity and the lumen of the gonads and nephridia.

8. Nervous system consists of paired cerebral, pleural, pedal and visceral ganglia joined by longitudinal and transverse connectives and nerves.

9. Circulatory system is closed type. Heart has one or two auricles and one ventricle.

10. Respiration direct or by gills or lungs or both. The respiratory pigment is haemocyanin.

11. Digestive system is complete. Digestive glands are liver or hepatopancreas. Radula is mostly present.

12. Excretion is performed by nephridia or kidneys.

13. Sexes are separate. Fertilization happens externally as well as internally.

14. Development is either direct or with metamorphosis through the trochophore stage called veliger larva.

Classification

Molluscs are classified into six classes according to their symmetry, their food habits, shell, mantle, gill, nervous system, muscles and radula.

Class1. Monoplacophora (Gr., monos = one + plax = plate + pherein = bearing)

1. Body is bilaterally symmetrical with internal metamerism.

2. Shell is flattened and limpet-shaped with spirally coiled protoconch.

3. Foot is broad, flat and bears 8 pairs of pedal retractor muscles.

4. Five pair of gills which are in pallial grooves.

5. There are six pairs of nephridia out of which two are modified into gonoducts.

6. Intestine is highly coiled. Radula present in radular sac.

7. Heart consists of two pairs of auricles and a single ventricle.

8. Nervous system with longitudinal, pallial and pedal cords.

Example: *Neopilina galathea*.

Class 2. Amphineura (Gr., amphi = both + neuron = nerve)

1. Body elongated with reduced head.

2. Radula is present.

3. Shell as 8 dorsal plates or as spicules.

4. Foot is ventral, large, flat and muscular.

5. Fertilization is external. Development happens via intermediate stage of trochophore larva.

6. Organisms are marine.

Subclass 1. Aplacophora

1. Body worm-like without shell and foot.

2. Radula is simple.

3. Calcareous spicules buried in cuticle.

4. A pair of bivalve ctenidia is present.

Examples: *Chaetoderma*, *Neomenia*, *Nematomerina*.

Subclass 2. Polyplacophora

1. Body is dorso-ventrally flattened; head small and without eyes and tentacles. Radula, shell, mantle, foot and external gills present.

4. Mantle cavity is present towards the back side.
5. Shell is in the form of 8 calcareous plates.

Order 1. Lepidopleurina

1. Shell valve are without plates.

2. Ctenidia few and posterior.

Example: *Lepidopleurus*.

Order 2. Chitonida

1. Shell valve are with plates.

2. Gills along whole length of mantle groove.

Examples: *Chiton*, *Chaetopleura*, *Ischnochiton*.

Class 3. Scaphopoda (Gr., scapha = boat + podos = foot)

1. Exclusively marine.

2. Body bilaterally symmetrical, elongated and enclosed in a tusk-like shell open at both ends.

3. Head and eyes absent; mouth with tentacles.

4. Foot conical; radula present.

5. Kidneys are paired and gonad is single.

6. Heart rudimentary.

7. Sexes are separate. Development includes trochophore larva.

Examples: *Dentalium*, *Pulsellum*, *Cadulus*.

Class 4. Gastropoda (Gr., gaster = belly + podos = foot)

1. Mostly marine, some freshwater, terrestrial, and few parasitic on echinoderms.

2. Includes snails and slugs.

3. Body is asymmetrical, unsegmented and generally with a univalve, spirally coiled shell.

4. Head well developed with eyes and tentacles.

5. Foot is large and flat.

Subclass 1.Prosobranchia

1. Mostly marine, few freshwater and terrestrial.

2. Body mass torted and head with a single pair of tentacles.

3. Shell closed by operculum.

4. Head distinct with snout bearing a pair of tentacles and a pair of eyes.

5. Foot is muscular and forms ventral part of the body.

6. Sexes are separate, gonad single, larva trochophore or veliger.

Order 1. Archaeogastropoda

1. One or two bipectinate internal gills.

2. Two kidneys and heart with two auricles.

3. Shell usually coiled.

4. Nervous system not concentrated usually with pedal cords.

5. Sexes are separate.

6. Fertilization is external.

Examples: *Patella, Trochus, Fissurella*.

Order 2. Mesogastropoda

1. Mostly marine, some freshwater.
2. One auricle, one kidney and one mono-pectinate ctenidium.
3. Radula taenioglossate type having 7 teeth in each row.
4. Single osphradium.
5. Nervous system without pedal cords.
6. Fertilization is internal.
7. Larva is a free-swimming veliger.

Examples: *Pila*, *Turbinella*, *Crepidula*, *Natica*, *Cypraea*.

Order 3. Neogastropoda

1. Shell with more or less elongated siphonal canal.
2. Nervous system concentrated.
3. Free- swimming veliger suppressed.

Examples: *Murex*, *Magilus*, *Buccinum*, *Melongena*, *Conus*, *Oliva*.

Subclass 2. Opisthobranchia

1. Exclusively marine gastropods.
2. Shell small, without operculum or no shell.
3. Body mass torted or detorted.
4. Gills posterior to heart.
5. One auricle, one kidney and one gonad.
6. Nervous system without pleuro-visceral loop.
7. Hermaphrodite, i.e., sexes united.

Order 1. Cephalaspidea

1. Shell moderately developed.
2. Parapodial lobes present or absent.
3. Head with tentacular shield.

Examples: *Acteon*, *Hydatina*, *Bulla*.

Order 2. Anaspidea

1. Found mostly in tropical and subtropical waters.
2. Shell reduced or internal.
3. Well developed parapodial lobes.
4. Head with a pair of rhinophores.

Examples: *Aplysia*, *Akera*.

Order 3. Pteropoda

1. Pelagic snails with or without shell.
2. Shell reduced or internal.
3. Parapodial lobes well developed.
4. Head with a pair of rhinophores.

Examples: *Corolla*, *Clione*, *Cavolina*.

Order 4. Sacoglossa

1. Shell can be present or absent.
2. Pharynx suctorial.
3. Sperm duct is closed.
4. Parapodia and cerata present.

Examples: *Elysia*, *Oxynoe*.

Order 5. Acochlidiaceae

1. Minute without shell.
2. Found in coarse sand.
3. Visceral mass separated from foot and covered with spicules.

Examples: *Acochlidium*, *Unela*.

Order 6. Notaspidea

1. Shell internal, external or reduced.
2. Mantle present but mantle cavity absent.
3. Gills bipectinate and osphradium on the right side.

Examples: *Tylodina, Pleurobranchus*.

Order 7. Nudibranchia

1. Shell absent.
2. Mantle or mantle cavity absent.
3. Internal gills and osphradium are absent.

4. Presence of dorsal outgrowths.

Examples: *Doris*, *Aeolis*.

Order 8. Pyramidellacea

1. Shell spirally twisted.

2. Proboscis long, operculum present but gill and radula absent.

3. Semi-parasitic forms.

Examples: *Pyramidella.*

Order 9. Philinoglossacea

1. Minute naked snails.

2. Head appendages and gills absent.

3. Visceral mass separated from foot only by a groove.

Examples: *Philinoglossa*, *Sapha*.

Order 10. Rhodopacea

1. Vermiform snails.

2. No external appendages.

3. Anus on right side of body.

Examples: *Rhodope.*

Order 11. Onchidiacea

1. Slug-like, naked or without shell opisthobranchs.

2. Pulmonary sac and anus placed at the posterior end

3. Male gonopore placed anteriorly while female gonopore placed posteriorly.

Examples: *Onchidella*, *Onchidium*.

Order 12. Parasita

1. Endoparasitic gastropods found in the interior of holothurians.

2. Shelled embryos.

Examples: *Thyonicola*, *Entoconcha*.

Subclass 3. Pulmonata

1. Mostly freshwater or terrestrial, a few are marine.

2. Detorted body mass.

3. Shell spiral or reduced or absent.

4. Mantle cavity or pulmonary sac with a pore on right side anteriorly.

5. Hermaphrodites.

Order 1. Basommatophora

1. Freshwater or brackish water and marine.

2. One pair of tentacles that is non-invaginable.

3. Eyes at tentacular bases.

4. Separate male and female gonopores.

Examples: *Lymnaea*, *Siphonaria*, *Planorbis*.

Order 2. Stylommatophora

1. Terrestrial pulmonates.

2. Two pairs of tentacles that are invaginable.

3. Second pair of tentacles with eyes at their tips.

4. Male and female gonopores are usually united.

Examples: *Limax*, *Partula*, *Helix*, *Retinella*.

Class 5. Pelecypoda (Gr., pelekus = batchet + podos = foot)

1. Aquatic, mostly marine, some freshwater forms.

2. Body bilaterally symmetrical and laterally compressed.

3. Head, tentacles, eyes, jaws as well as radula absent.

4. Foot hatchet-shaped and extending between mantle lobes.

5. Gills or ctenidia are paired, one on each side.

6. Dioecious, veliger or glochidium larva in the life-history.

Order 1. Protobranchia

1. Gill filaments not folded.

2. Mouth placed at the base of proboscides.

3. Style sac is present in the stomach.

Examples: *Nuculina*, *Nucula*, *Yoldia*, *Malletia*.

Order 2. Filibranchia

1. Gill filaments incompletely fused.

2. Chitinous gastric shield in stomach developed.

3. Foot is small or poorly developed.

4. Style sac with crystalline style.

Examples: *Mytilus*, *Ostrea*, *Pecten*, *Spondylus*.

Order 3. Eulamellibranchia

1. Gills are firm and basket-like.

2. Gill filaments fused completely to form tissue sheets.

3. Foot usually large and byssus reduced or absent.

Examples: *Unio*, *Teredo*, *Anodonta*, *Lamellidens*, *Enis*.

Order 4. Septibranchia

1. Marine forms.

2. Gills absent.

3. Stomach lined by chitin; style-sac reduced.

Examples: *Poromya*, *Cuspidaria*.

Class 6. Cephalopoda (Gr., kephale = head + podos = foot)

1. Exclusively marine.

2. Bodybilaterally symmetrical.

3. Shell internal, external or absent.

4. Head bears highly developed eyes and mouth.

5. Foot modified into tentacles and siphon.

6. Sexes are separate.

7. Development meroblastic without metamorphosis.

Subclass 1. Nautiloidea or Tetrabranchiata

1. Shell external, coiled or straight.

2. Tentacles without suckers.

3. Two pair of gills and that of nephridia present.

Example: *Nautilus*.

Subclass 2. Ammonoidea

1. Extinct.

2. Shell external and coiled.

Example: *Pachydiscus*.

Subclass 3. Belemnoidea or Dibranchiata

1. Shell internal or reduced.

2. Tentacles few and with suckers.

3. One pair of gills and that of nephridia present.

Order 1. Decapoda

1. Ten arms present. Two are long and act as tentacles while rests of the arms are short.

2. Shell is internal and well developed.

3. Mostly scavangers.

Examples: *Loligo*, *Sepia*, *Spirula*.

Order 2. Octopoda

1. Body is short or compact.

2. Eight equal arms.

3. Dorsal mantle cavity present (Kotpal, 2005).

Examples: *Octopus, Argonauta*.

8.3 Identification, systematic position and general study
8.3.1- *Chiton and Dentalium*

Chiton:

Systematic position:

Phylum	Mollusca
Class	Amphineura
Order	Chitonida
Genus	*Chiton*

Comments:

1. Body of *Chiton* (Fig. 1) is bilaterally symmetrical, unsegmented and dorso-ventrally compressed.

2. It consists of shell, foot, mantle and the visceral mass.

4. Shell is calcareous and is present on the dorsal side and is composed of eight overlapping plates.

5. Head is not distinct. Eyes and tentacles are absent.

6. Foot is ventral, broad, sole-like and muscular, adapted for creeping and adhering.

7. Mantle covers greater part of body and partly covers the edges of the shell plates.

8. Mouth and anus are at opposite ends.

9. Sexes are separate; gonad is single and is located in the front of the heart.

10. Excretory system consists of two nephridia.

11. Development is indirect through trochophore larva.

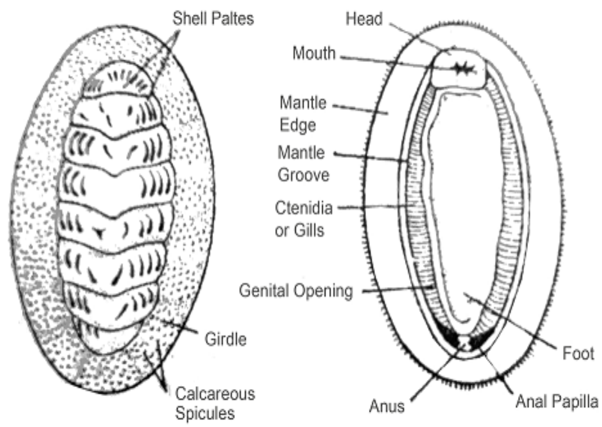
12. Chitons are eaten as food and their shells are used for decoration.

Habit and habitat:

Chiton is marine animal found attached to the rocks and corals between tide marks. It creeps along slowly on a muscular foot (Verma, 2015).

Distribution:

Chiton is found all over the world.



(A) (B)

Fig 1. *Chiton* (A) Dorsal view (B) Ventral view

DENTALIUM:

Systematic position:

Phylum Mollusca

Class Scaphopoda

Genus *Dentalium*

Comments:

1. *Dentalium* (Fig. 2) is commonly known as tusk shell.

2. It measures 2-5 cm in length.

3. It lies in a tubular, bilaterally symmetrical shell open at both ends.

4. Head and foot project out from the anterior aperture of the shell. Head bears a mouth surrounded by filiform tentacles called captacula. Eyes and osphradium are absent.

5. Mantle is entirely within the shell.

6. The foot is long pointed, spade-like and highly extensible adapted for digging and burrowing.

7. Sexes are separate.

8. Development is indirect and includes a veliger larva.

9. Shell of *Dentilium* is used for ornamental purposes. Its shells were once used by Red Indians of America as currency.

Habit and habitat:

Dentalium is marine and found in the sand at great depth. It feeds on microscopic organisms, detritus and foraminifera.

Distribution:

They are found in all seas except polar.

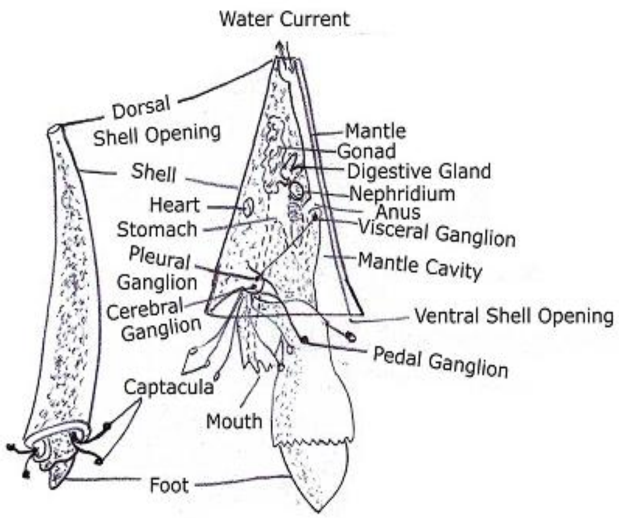


Fig. 2. *Dentalium*

8.3.2- *SEPIA AND PATELLA*

SEPIA:

Systematic position:

Phylum Mollusca

Class Cephalopoda

Order Decapoda

Genus *Sepia*

Comments:

1. *Sepia* (Fig. 3) is commonly called cuttle fish which is a misnomer because it is actually a mollusc and not a fish.

2. Body is soft, unsegmented and bilaterally symmetrical. It is divisible into a large head, a small neck or collar and trunk.

3. The head is well developed, bears a pair of eyes and 10 oral arms which are a modification of foot. 8 oral arms are smaller while two are longer and are called tentacles.

4. Collar is constricted and connects the head with the trunk.

5. The trunk extends into flaps called lateral fins on either side that help the animal in swimming.

6. It is covered by a thick muscular mantle, enclosing a large mantle cavity, on the ventral side which contains viscera.

7. It has a life expectancy of 1-2 years.

8. The Sexes are separate and reproduction is sexual.

9. Ornament makers use cuttle bones as moulds for casting small objects.

Habit and habitat:

Sepia is a marine animal that resides shallow to mid water and is often associated with coral reefs. It is carnivorous, feeds on crustaceans, small fishes and other animals.

Distribution:

Sepia is cosmopolitan in distribution. It is commonly found in Europe, India and Mediterranean region.

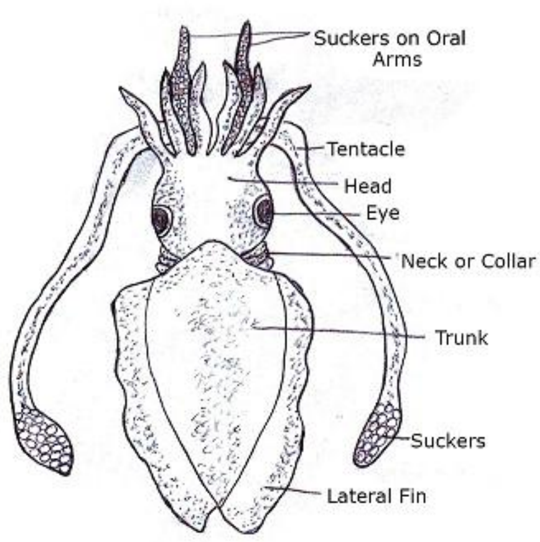


Fig. 3. *Sepia*

***PATELLA*:**

Systematic position:

Phylum Mollusca

Class Gastropoda

Order Archaeogastropoda

Genus *Patella*

Comments:

1. *Patella* (Fig. 4) is commonly known as true limpet.

2. Shell is oval and rounded without operculum.

3. The head bears one pair of stout, sensory tentacles and eyes.

4. Mantle cavity is restricted anteriorly.

5. Foot is ventral, broad and flat used for adhering and creeping.

6. *Patella* is eaten in several countries like France, Italy and Ireland.

7. The shells of *Patella* are used in decoration.

8. Sexes are separate.

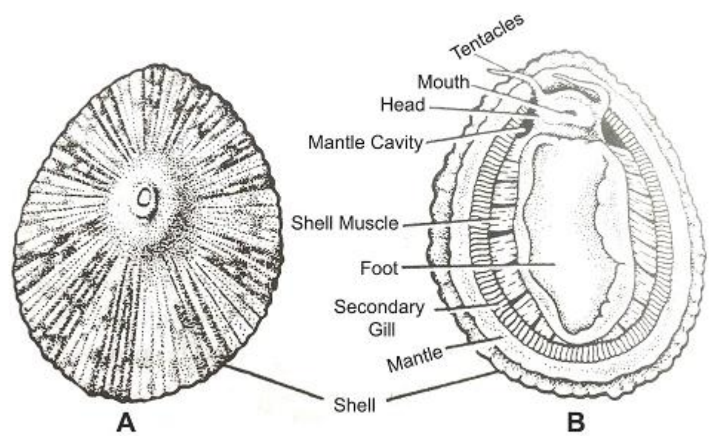
9. Development is indirect involving a free swimming larva.

Habit and habitat:

Patella is a sluggish marine gastropod. It attaches itself to the rocks and feed on minute algae.

Distribution:

Patella is found on the rocky ocean coasts worldwide.



(A) Dorsal View (B) Ventral View

Fig. 4. *Patella*

8.3.3- *PILA AND TURBINELLA*
PILA GLOBOSA:

Systematic position

Phylum	Mollusca
Class	Gastropoda
Order	Mesogastropoda
Genus	*Pila*
Species	*globosa*

Comments:

1. *Pila gobosa* (Fig. 5) is commonly called apple snail.

2. Shell is univalve and coiled around a central axis in a right handed spiral.

3. Operculum is well developed and closes the aperture or the mouth of the shell.

4. The body is soft and is enclosed in a shell. It consists of head, foot and visceral mass.

5. Head is the anterior fleshy part of the body overhanging the foot. It bears mouth, two pairs of contractile tentacles and a pair of eyes.

6. Foot is the locomotory organ of *Pila* and lies below the head.

7. All visceral organs are contained in this lump like structure that lies above the head-foot complex.

8. Skin of the visceral mass forms a thin and delicate covering called the mantle.

9. Respiratory organs consist of a single ctenidium or gill, a pulmonary sac or lung and a pair of nuchal lobes. Aquatic respiration by ctenidium and aerial respiration by pulmonary chamber.

10. Sexes are separate but without sexual dimorphism.

11. It is found in large numbers in those areas which are rich in aquatic plants like *Vallisneria* and *Pistia* (Rastogi, 2015).

Habit and habitat:

Pila is commonly found in freshwater ponds, lakes, tanks, pools, marshes, paddy fields, streams and rivers of Northern India**.** They are amphibious being adapted for life in water and on land. It creeps slowly using its ventral muscular foot.

Distribution:

Pila is confined to the Oriental and Ethiopian regions.

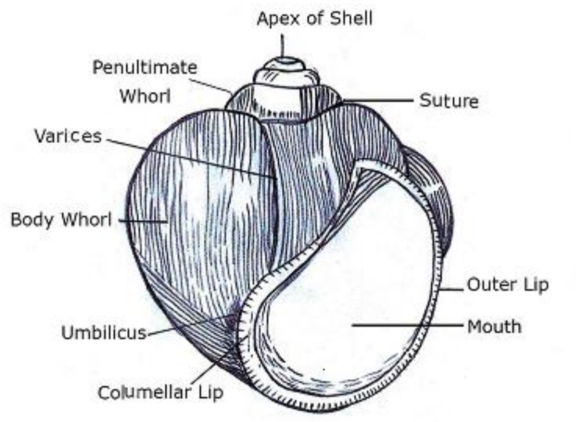


Fig. 5. *Pila*

***TURBINELLA*:**

Systematic position

Phylum Mollusca

Class Gastropoda

Order Mesogastropoda

Genus *Turbinella*

Comments:

1. Body of *Turbinella* (Fig. 6) is unsegmented and asymmetrical.

2. Body is present in a large, thick fusiform shell.

3. Shell is spirally coiled with 3 or 4 prominent columellar plicae.

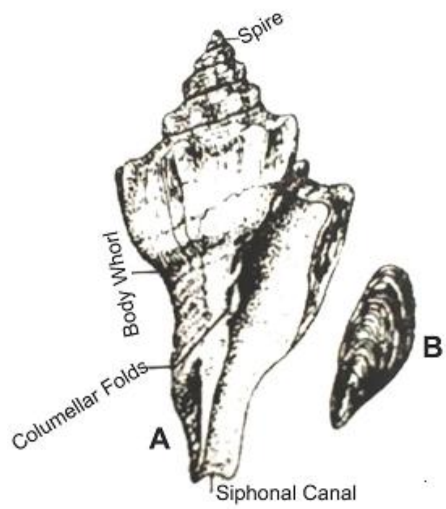
4. Head bears a pair of eyes, a pair of tentacles and an eversible proboscis which bears the mouth.

5. Mantle encloses the visceral mass and forms a collar like margin for the shell aperture.

6. A large foot with a calcareous, heavy operculum projects out of the shell for locomotion and attachment (Yadav and Varshney, 2015).

Habit and habitat:

It is a marine animal found worldwide mostly in tropical shallow waters.



(A) Ventral View (B) Operculum

Fig. 6. *Turbinella*

8.3.4- *APLYSIA* AND SLUG

APLYSIA

Systematic position

Phylum Mollusca

Class Gastropoda

Order Anaspidea

Genus *Aplysia*

Comments:

1. *Aplysia* (Fig. 7) is commonly known as sea-hare.

2. The body is bilaterally symmetrical, soft and lumpy with a thin flexible plate-like shell covered by mantle.

3. The head has two pairs of tentacles. The posterior pair tentacles become ear-like and are called rhinophores.

4. Mantle possesses unicellular ink glands. These secrete purple ink used for defence.

5. The foot is broad and flat and bears a pair of lateral folds parapodia that help in swimming.

6. Anus lies at the posterior end.

7. It is bisexual. It has a single gonoduct.

8. *Aplysia* feeds mainly on the sea weeds.

Habit and habitat:

Aplysia is a marine gastropod found crawling in sea weeds. It is herbivorous. It changes its color according to the color of sea weeds it eats.

Distribution:

Aplysia is found in most parts of of the world from the Arctic to the Antarctic.

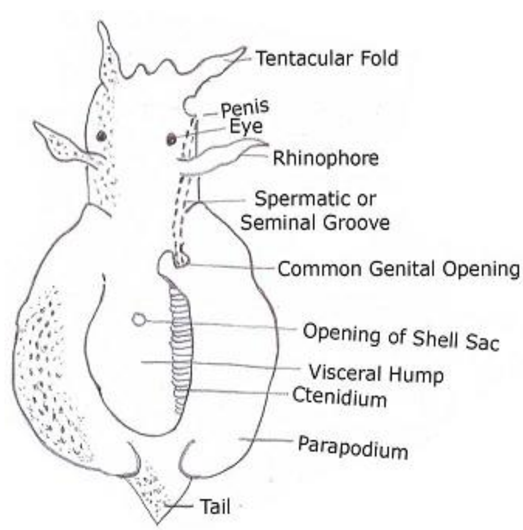


Fig. 7. *Aplysia*

EOLIS:

Systematic position

Phylum Mollusca

Class Gastropoda

Order Nudibranchia

Genus *Eolis*

Comments:

1. *Eolis* (Fig. 8) is commonly known as sea slug.

2. Body is soft, about 5 cm in length and orange with brown spots.

3. Head bears two pair of cylindrical retractile tentacles and sessile eyes at the base of the posterior pair of tentacles.

4. The mouth is prominent and can be most easily seen from the ventral view. Locomotion happens via foot which is muscular and ventral.

5. Shell, mantle and true gills are absent.

6. Anus is situated at the dorsal surface.

7. It is hermaphroditic.

8. It is used in traditional medicines in the Far East.

Habit and habitat:

Eolis inhabits shallow waters, found often crawling on the underside of sea weeds. It feeds on plankon and decaying matter on the ocean floor along with grazing on the rocks and coral reefs for algae.

Distribution:

Eolis is found in Europe, Rhodes Island to Arctic Ocean and U.S.A.

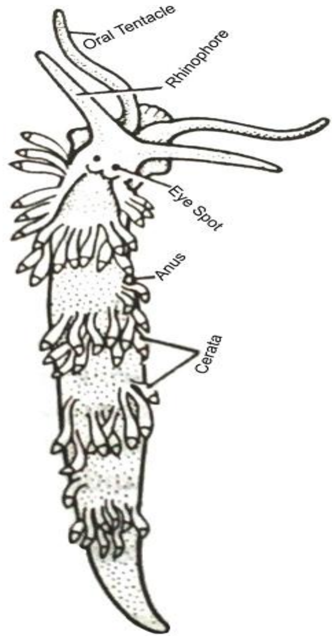


Fig. 8. *Eolis*

HELIX

Phylum	Mollusca
Class	Gastropoda
Order	Stylommatophora
Genus	*Helix*

Comments:

1. *Helix* (Fig. 9) is commonly called garden snail.

2. Body is enclosed in a shell and divisible into head, foot and visceral hump.

3. Shell is thin and bears prominent lines of growth.

4. Head bears two pairs of tentacles, the smaller pair bears smell organs and the larger pair bears a pair of simple eyes.

5. Mouth is located underneath the head.

6. Foot possesses a flat ventral surface and used for creeping.

7. Respiration by pulmonary sac or lung.

8. Hermaphrodite.

9. Some snails may live more than 30 years but most live less than 8 years.

9. Snails are eaten the world over. Snail eggs are a speciality food in certain European countries.

Habit and habitat:

Helix is terrestrial rather than marine. It is generally herbivorous however there are some species that are carnivorous or omnivorous. In winter it hibernates in the soil.

Distribution:

Helix is found in Palearctic region.

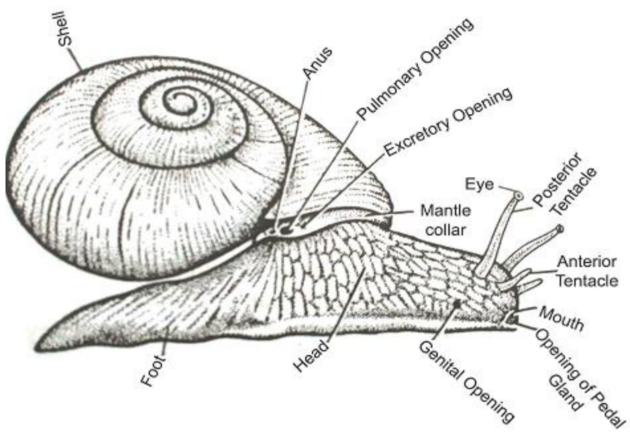


Fig. 9. Helix

Mytilus:

Systematic position:

Phylum Mollusca

Class Pelecypoda

Order Filibranchiata

Genus *Mytilus*

Comments:

1. *Mytilus* (Fig. 10) is commonly known as sea mussel.

2. Body is enclosed in a wedge-shaped shell and can be divided into head, foot, visceral mass and mantle.

3. The shell is bivalve with the anteriorly placed umbo and encloses internal structures such as gills, kidney, heart, alimentary canal.

4. A pair of simple eyes is found.

5. A pair of gills is present, each gill having gill filaments.

6. Foot is long, cylindrical and has a ventral groove continuous with a byssus pit.

7. Sexes are separate.

Habit and habitat:

Mytilus is marine, sedentary and found attached to the rocks between tidemarks.

Distribution:

Mytilus is cosmopolitan in distribution. It is commonly found in Europe, India and U.S.A.

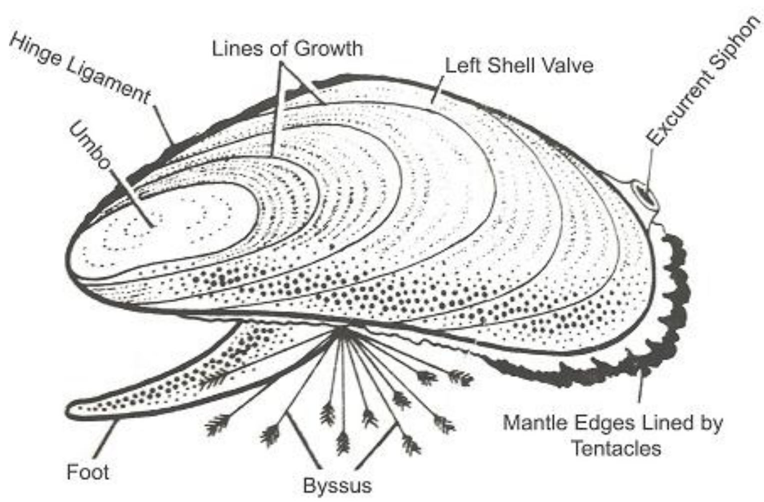


Fig. 10. *Mytilus*

OCTOPUS:

Systematic position:

Phylum	Mollusca
Class	Cephalopoda
Order	Octopoda
Genus	*Octopus*

Comments:

1. An *Octopus* (Fig. 11) is commonly called devil fish.

2. The body is unsegmented, symmetrical and soft bodied animals.

3. The head bears a pair of eyes. The mouth is surrounded by eight elongated equal arms usually bearing suckers.

4. Shell is absent.

5. It moves around by crawling or swimming.

6. For defence it ejects ink from the ink-gland into the surrounding water, producing a smoky cloud.

7. In males one of the arms, called hectocotylized arm, bears a spoon shaped organ at its end. The arm is used to caress the female and deposit spermatophores beneath its mantle.

8. Sexes are separate.

9. Development is direct.

10. It feed upon crabs, bivalves and fishes etc.

Habit and habitat:

Octopus is a nocturnal marine creature inhabits many diverse regions of the ocean, including coral reefs, pelagic waters and the ocean floor.

Distribution:

Octopus is cosmopolitan in distribution. It is generally found in Europe, India, Pacific and Atlantic coasts.

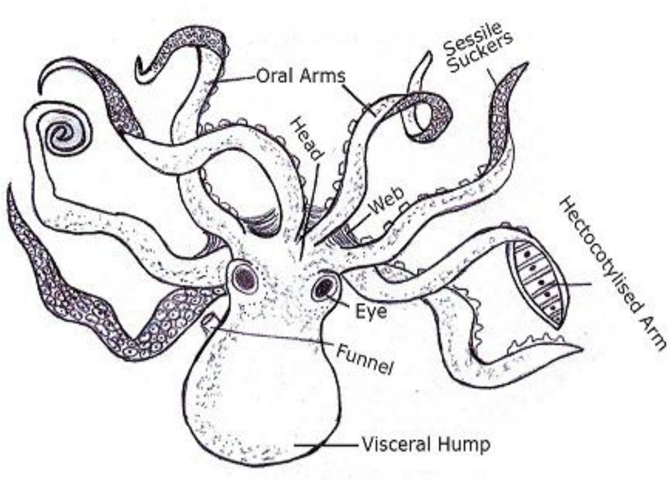


Fig. 11. Octopus

8.4- T. S. of glochidium larva:

Comments

1. Glochidium larva (Fig. 12) is found in the development of pelecypoda or bivalvia.

2. It is a minute larva measuring 0.1 to 0.4 mm, comprises a bivalve shell and false mantle lining the shell.

3. Shell consists of two trinangular valves which are convex externally and concave internally. The valves are attached to each other on dorsal side only.

4. Ventral end of each valve is like curved hook bearing spines.

5. Mantle lobes are small bearing brush-like sensory organs.

6. The closure of the valves is effected by the large adductor muscle present between them.

7. Byssus gland is situated above the adductor muscle which gives rise to a long sticky thread, called provisional byssus.

8. Glochidium larva leads a parasitic life for about 10 weeks before metamorphosis into adult. It does show by attaching itself to the skin or gills or fins of a fish through hooked ventral ends (Wikipedia).

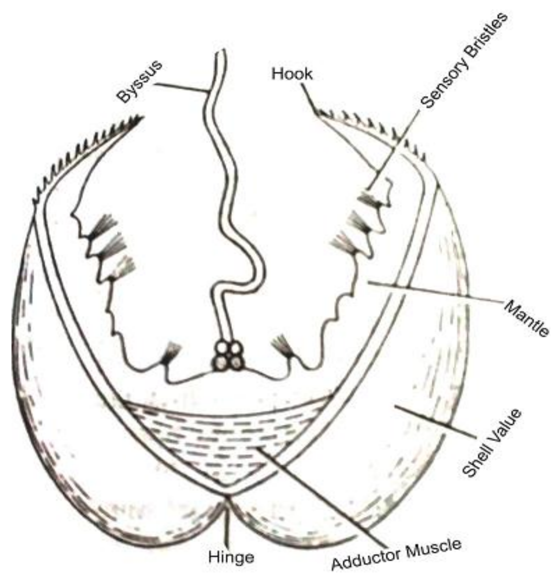


Fig. 12. T. S. of glochidium larva of *Unio*

8.5 T. S. of *Unio* through Anterior Region:-

Comments:

1. Sections of shell, mantle, foot and other structures are seen (Fig. 13).

2. The two shell valves are connected at the top and open at the bottom.

3. Club shaped foot occupies major portion of mantle cavity.

4. Inner and outer gill-laminae are present on either side of the foot. Each gill lamina is made up of two folds called outer and inner gill-lamellae.

5. Sections of keber's organ, bladder, kidney, rectum, intestine and gonads are seen at their respective places.

6. Pericardial cavity, within the mantle cavity, surrounds a pair of auricles and a ventricle.

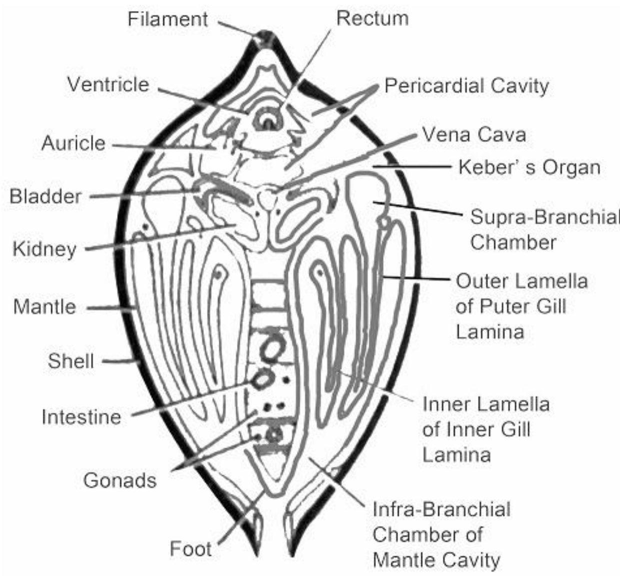


Fig. 13. T. S. of *Unio* through Anterior Region

8.6 - T. S. of *Unio* through Posterior Region

Comments:

1. Sections of shell and mantle are seen (Fig. 14).
2. The two shell valves are connected at the top and open at the bottom.
3. Anteriorly section of rectum is seen. Well developed posterior adductor muscle can be seen below rectum.
4. Below the posterior adductor muscle lies the visceral ganglion.
5. Mantle is seen associated with gill-laminae. Each gill-lamina is made up of outer and inner gill lamellae.
6. Supra-branchial chamber and infra-branchial chamber of mantle cavity are seen.

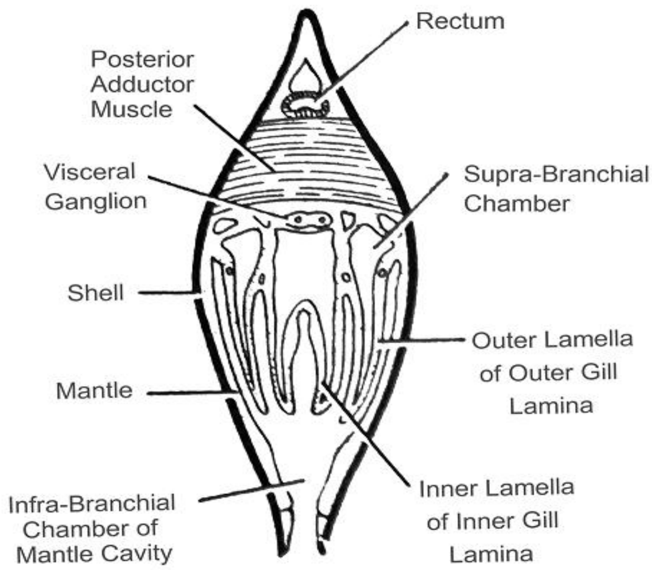


Fig. 14. T. S. of *Unio* through Posterior Region

T. S. of Gill of *Unio*

Comments:

1. Each gill is composed of inner laminae and the outer laminae (Fig. 15).
2. Each lamina is made of two lamellae; outer and inner lamella.The lamellae are free dorsally but are attached to each other at their anterior, ventral and posterior edges at regular intervals by inter-lamellar junctions forming a series of ventral compartments or water pleats.
3. Each gill-lamella is composed of a series of thin vertical gill-filaments which are connected to one another by horizontal bars or inter-filamentar junctions.

5. Minute apertures or Ostia are present between the gill filaments that open into the water tube.

6. Gill filaments are covered with ciliated epithelium and are supported by internal chitinous rods.

7. Afferent and efferent branchial vessels are present on the outer edges of each inter-lamellar junction (Verma, 2015).

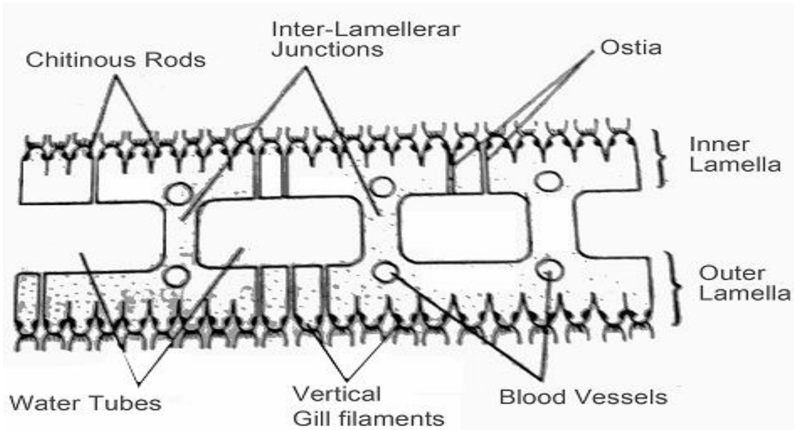


Fig. 15. T. S. of Gill of *Unio*

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UNIT 9: PHYLUM ECHINODERMATA

General characters:-

1. Echinoderms (Gr. Echinos=hedgehog+derma=skin) are exclusively marine, free living and mostly bottom-dwellers.

2. Body triploblastic, coelomate and symmetrical.

3. Organ system grade of body organization.

4. Body unsegmented with star-like, spherical, globular, discoidal or elongated with radiating arms.

5. Head is absent. Body is generally pentameric.

6. Body surface with five radial areas, the ambulacra, with tube feet and five inter-radial areas, the inter-ambulacra.

7. Coelom is a large cavity lined by ciliated peristomium, coelomic fluid with coelomaocytes.

8. Endoskeleton is made up of spines and calcareous spicules.

9. Water vascular system or ambulacral system present, usually with a madreporite.

10. Sense organs are poorly developed.

11. Nervous system consists of a circum-oral ring and radial nerves. Brain is absent.

12. Respiratory organs include tube feet, respiratory tree, dermal branchiae and bursae.

13. Alimentary canal straight or coiled.

14. Circulatory or haemal or blood lacunar system is typically present.

15. Excretory organs absent.

16. Reproduction is usually sexual but few reproduce asexually or by regeneration.

17. Sexes are separate. Fertilization is external and development indirect through free-swimming larval forms.

Classification

Subphylum 1. Eleutherozoa (Gr., eleutheros=free+zoios=animal)

Class 1. **Asteroidea** (Gr., aster= star + eidos = form)

1. Starfishes or sea stars.

2. Body includes five radiating arms.

3. Tube feet with suckers.

4. Pedicellariae present.

5. Free-living, slow creeping and scavengerous.

Subclass 1. **Somasteroidea**

1. Fossil Palaezoic sea stars. *Platasterias latiradiata* is the only living species.

Subclass 2. **Euasteroidea**

1. Living sea stars.

Order 1. **Phanerozonia**

1. Body with marginal plates and papulae on aboral surface.

2. Tube feet without suckers.

3. Pedicellariae alveolar or sessile type.

4. It mostly lives in burrows in soft bottom.

Examples: *Goniaster, Astropecten*, *Oreaster, Luidia*.

Order 2. **Spinulosa**

1. Without conspicuous marginal plates but with papulae on both surfaces.

2. Tube feet with suckers.

3. Pedicellariae is rarely present.

4. Aboral surface with low spines.

Examples: *Echinaster*, *Asterina*, *Solaster, Pteraster*.

Order 3. **Forcipulata**

1. Marginal plates inconspicuous or absent.

2. Four rows of tube feet present.

3. Pedicellariae pedunculate and straight or crossed.

Examples: *Asterias*, *Heliaster*.

Class 2. **Ophiuroidea** (Gr., ophis = snake + oura = tail + eidos = form)

1. Includes brittle stars and allies.

2. Arms usually five, rarely six or seven, and are long, slender, smooth or spiny.

3. Body flattened with a pentamerous and has rounded central disc.

4. Pedicellariae is absent.

5. Tube feet without suckers.

Order 1. **Ophiurae**

1. Brittle and serpent stars.

2. Small and five-armed.

3. Arms move transversely.

4. Single madreporite.

Examples: *Ophiothrix, Ophioderma, Ophiopholis, Ophiura*.

Order 2. **Euryalae**

1. Arms are simple and branched, vertical movement.

2. Disc and arm covered by soft skin.

3. one madreporite in each inter-radius.

Examples: *Asteronyx*, *Gorgonocephalus* (basket star).

Class 3. **Echinoidea** (Gr., echinos = hedgehog + eidos = form)

1. Sea urchins and sea dollars.

2. Body spherical, disc-like, oval or heart-shaped.

3. Chewing apparatus or Aristotle's lantern with teeth.

4. Skeleton with movable spines and three-jawed pedicellariae.

5. Sexes are separate.

Subclass 1. **Bothriocidaroida**

1. A single row of plates in each inter-ambulacral area.

2. Without typical lantern.

Examples: Single extinct Ordovician genus *Bothriocidaris.*

Subclass 2. **Regularia**

1. Body pentamerous, globular, with two rows of inter-ambulacral plates.

2. Aristotle's lantern well developed.

3. Mouth central.

4. Madreporite oral.

Order 1. **Lepidocentroida**

1. Test flexible with overlapping plates.

2. Ambulacral plates extend up to mouth lip.

3. Inter-ambulacral plates in more than two rows in extinct forms.

Example: *Palaeodiscus* , *Phormosoma.*

Order 2. **Melonechinoida**

1. Test spherical and rigid.

2. Inter-ambulacral plates in four or more rows.

3. Ambulacral plates continue to mouth lip.

4. Wholly extinct.

Example: *Melonechinus*.

Order 3. **Cidaroida**

1. Test globular and rigid.

2. Two rows of long narrow ambulacral plates and two rows of inter-ambulacral plates.

3. No peristomial gills.

4. Anus aboral and central.

Examples: *Goniocidaris, Histocidaris, Cidaris.*

Order 4. **Diadematoida**

1. Test globular usually with compound ambulacral plates.

2. Anus aboral and central.

Examples: *Echinus*, *Arbacia*, *Diadema*.

Subclass 3. **Irregularia**

1. Body circular or oval flattened oral-aborally.

2. Mouth central or displaced anteriorly on oral surface.

3. Anus marginal, outside the apical system of plates.

4. Tube feet generally not locomotor.

Order 1. **Holectypoida**

1. Test regular with simple ambulacra and centrally located peristome and apical system.

2. Lantern present.

3. Mostly extinct.

Examples: *Echinoneus*, *Holectypus*.

Order 2. **Cassiduloida**

1. Aboral ambulacra area petloid, forming a five-armed figure like petals of a flower.

2. Lantern absent.

3. Mostly extinct.

Examples: *Cassidulus*.

Order 3. **Clypeastroida**

1. Test flattened with oval or rounded shape.

2. Mouth central, anus excentric.

3. Aboral ambulacral areas petaloid.

4. Bottom dwellers.

Examples: *Echinarachinus, Clypeaster, Echinocyamus*.

Order 4. **Spatangoid**

1. Test oval or heart-shaped with excentric mouth and anus.

2. Four aboral ambulacral areas paloid.

3. Lantern absent.

4. Burrowing forms.

Examples: *Hemipneustes*, *Spatangus*, *Echinocardium lovenia*.

Class 4. **Holothuroidea** (Gr., holothurion = sea cucumber + eidos = form)

1. Sea cucumbers.

2. Body elongated, bilaterally symmetrical in the oral-aboral axis having mouth at or near one end and anus at or near the other end.

3. Arms and spines are absent.

4. Mouth anterior, surrounded by tentacles.

5. Respiration takes place *via* respiratory tree.

Order 1. **Dendrochirota**

1. Tentacles irregularly branched.

2. Numerous tube feet.

3. Respiratory tree are present.

Examples: *Cucumaria*, *Thyone*.

Order 2. **Aspidochirota**

1. Tentacles peltate or leaf-like.

2. Numerous podia or tube feet.

3. Pharynx absent.

4. Respiratory tree present.

Examples: *Holothuria*, *Actinopyga*.

Order 3. **Elasipoda**

1. Tentacles leaf-like.

2. Tube feet webbed together to form fins.

3. Respiratory tree absent.

4. Deep-sea dwellers.

Examples: *Pelagothuria*.

Order 4. **Molpadonia**

1. Fifteen digitate tentacles.

2. Tube feet are absent.

3. Respiratory tree present.

Examples: *Molpadia, Caudina*.

Order 5. **Apoda**

1. Worm-like sea cucumbers.

2. Respiratory tree or tube feet absent.

3. Burrowing forms.

Examples: *Leptosynapta*, *Synapta*.

Subphylum II. **Pelmatazoa** (Gr., pelmatos = stalk + zooios = animal)

Stalked, sedentary echinoderms.

Class 1. **Crinoidea** (Gr., crinon = lily + eidos = form)

1. Sea lilies.

2. Body attached during part or whole life by an aboral stalk.

3. Mouth and anus on oral surface.

4. Arms with pinnules.

5. Tube feet without suckers; madreporite, spines and pedicellariae absent.

Order. **Articulata**

1. Living sea lillies and feather stars.

2. Calyx pentamerous.

3. Feather stars are sessile and free-swimming.

Examples: *Antedon*, *Neometra*.

9.3- IDENTIFICATION, SYSTEMATIC POSITION AND GENERAL STUDY

ECHINUS:

Systematic position:

Phylum Echinodermata

Class Echinoidea

Order Camarodonta

Genus *Echinus*

Comments:

1. *Echinus* is commonly called sea-urchin (Fig 1).

2. It has a globe-shaped body enclosed within a shell or corona and having very long movable spines. The surface of corona is divided into five ambulacral regions alternating with five interambulacral regions. In each ambulacral region, there are two rows of tube feet.

3. Mouth is present on oral surface and is surrounded by peristome. The chewing apparatus or Aristotle's lantern projects from the mouth. Anus is surrounded by a periproct and is present in the centre of the aboral surface.

4. Water-vascular system is well developed.

5. Development is indirect and involves free swimming echinopluteus larva.

6. Sexes are separate. Gonads are five large masses.

Habit and habitat:
Echinus is marine, found in the sea in the rocky places.

Distribution:

Echinus is widely distributed in the Atlantic, Mediterranean and Pacific Oceans.

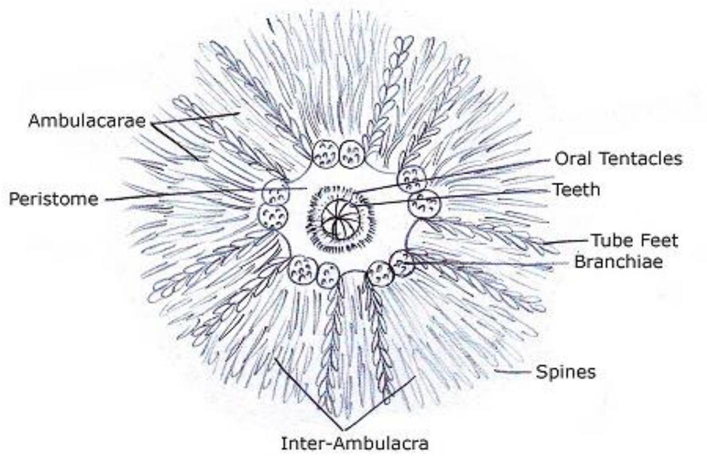


Fig. 1 *Echinus*

HOLOTHURIA:

Systematic position:

Phylum Echinodermata

Class Holothuroidea

Order Aspidochirota

Genus *Holothuria*

Comments:

1. *Holothuria* is commonly known as sea-cucumber (Fig. 2).

2. It is found in nearly every marine environment, but is most diverse on tropical shallow-water coral reefs.

3. The body is sausage-shaped, elongated, covered with leathery skin and having well developed respiratory tree.

4. Mouth is anteriorly placed, surrounded by 15-30 peltate tentacles.

5. Sexes are separate.

6. Development includes two larval stages doliolaria and auricularia respectively.

7. *Holothuria* feeds by pushing sand containing organic food into mouth with the help of tentacles.

Habit and habitat:

Holothuria is found in shallow tropical and subtropical waters of Indo-Pacific area, lying together in thousands on the sandy bottom, fully exposed or somewhat hidden under plants or shell bits, etc.

Distribution:

Holothuria is found distributed in India, West Indies and Florida.

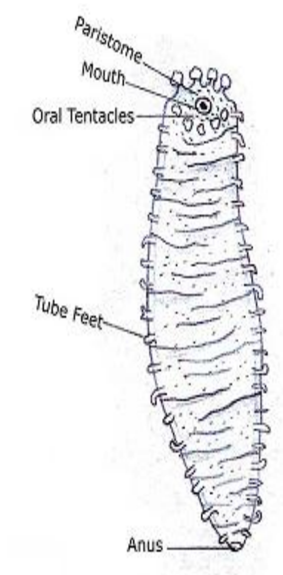


Fig. 2 *Holothuria*

PENTACEROS:

Systematic position:

Phylum Echinodermata

Class Asteroidea

Order Phanerozonia

Genus *Pentaceros*

1. *Pentaceros* is known as sea pentagon.

2. The body is very thick and regular star-shaped and has a diameter of about 25 cm.

3. Central disc is large and the five arms are short and tapering.

4. Aboral surface is convex and bears rows of definitely arranged spines. Oral surface is concave, having a central mouth, communicating with five ambulacral groves, each bearing two double rows of tube feet.

5. Pedicellariae are small and valvate type.

6. Sexes are separate.

7. Development indirect which includes bipinnaria larva.

8. *Pentaceros* is very harmful to pearl industry as it feeds on pearly oysters (Fig. 3).

Habita and habitat:

Pentaceros is marine. It feeds on oysters, thus, it is very harmful to the pearl industry.

Distribution:

Pentaceros is found commonly in the Indo-Pacific Ocean and around the West Indies; in the Bay of Bengal and Arabian Sea.

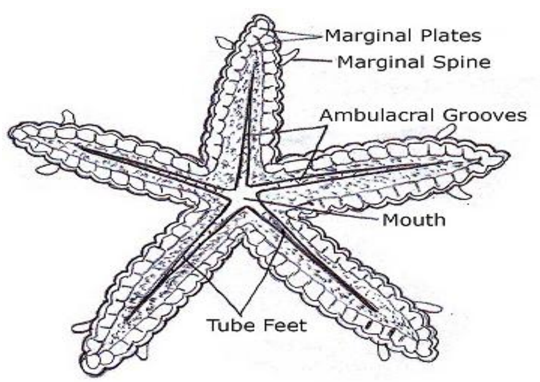


Fig. 3 *Pentaceros*

OPHIOTHRIX

Systematic position:

Phylum Echinodermata

Class Ophiuroidea

Order Ophiurae

Genus *Ophiothrix*

Comments:

1. *Ophiothrix* is a commonly known as spiny brittle star.
2. It has a small rounded central disc and five slender jointed arms arising from the lower suface to the disc.
3. The arms are covered on all sides by the plates or shields finged with spines.
4. The oral surface also bears five oral shields and podial-pores.
5. The tube feet without suckers are present on the lower plates of arms.
6. *Ophiothrix* possesses a great power of regenerating its lost arm (Fig. 4)

Habit and habitat:

It is cosmopolitan but more abundant in tropical waters. It feeds on decaying matter and microbes found on soft muddy bottoms.

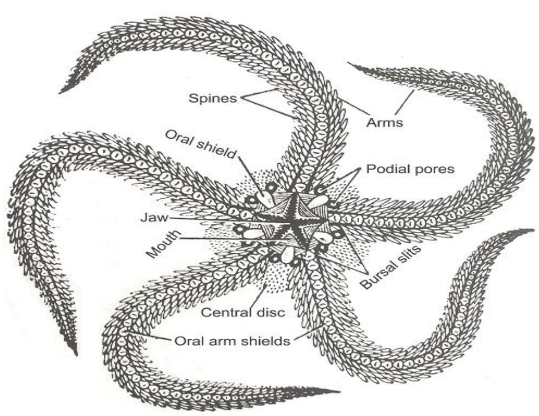


Fig. 4 *Ophiothrix*

***ASTERIAS* (STAR FISH)**

Systematic position:

Phylum	Echinodermata
Class	Asteroidea
Order	Forcipulata
Genus	*Asterias*
Species	*rubens*

Comments:

1. *Asterias* is commonly known as starfish or sea star (Fig. 5).

2. Average size of *Asterias* ranges from 10 to 25 cm in diameter.

3. The body is star shaped, consisting of a central disc with five radiating arms which are broad at their base and tapering towards their extremities.

4. Mouth is pentagonal and lies in the centre of the disc on oral surface.

5. Aboral surface bears a number of short, stout spines arranged in irregular rows, numerous dermal branchiae among spines and a smaller aperture, the anus which is situated near the centre.

6. Pedicellariae are very small, microscopic bodies scattered all over the body.

7. Water vascular system is well developed.

8. Sexes are separate. Fertilization is external.

9. Development includes a free swimming bippinnaria larva.

Habit and habitat:

Asterias are free-living marine animals that can be found at all water depths as well as crawling over rocks and shells *Asterias* is a marine form and found in the sandy and rocky parts of the sea.

Distribution:

Asterias is found in shallow water in North Temperate seas and found abundantly on North-Atlantic coast. It is found in abundance in India and U.S.A.

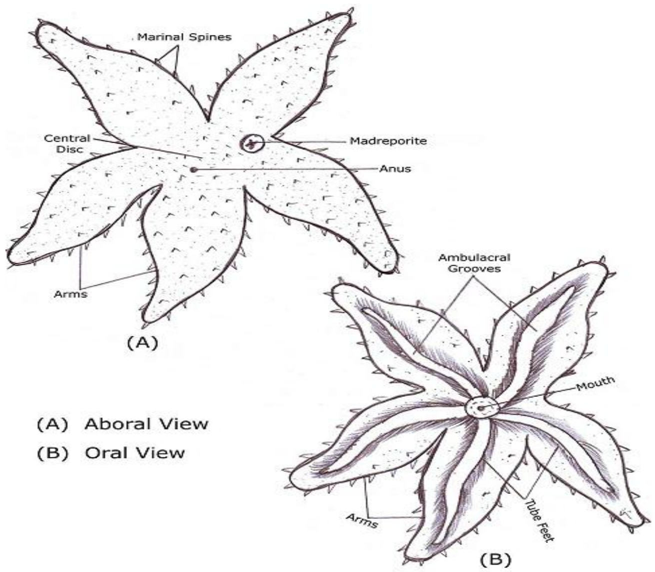


Fig. 5 *Asterias*

ANTEDON:

Systematic position:

Phylum	Echinodermata
Class	Crinoidea
Order	Articulata
Genus	*Antedon*

Comments:

1. *Antedon* is commonly known as feather star (fig. 6).

2. Body consists of a central disc or calyx and a series of five radiating arms.

3. It has a central leathery disc covered with bony plates with oral and aboral surfaces.

4. Each arm is divided at its base into two, so that there are ten long slender flexible arms, bearing lateral pinnules.

5. Tube feet without suckers present along the edges of ambulacral grooves.

6. Sexes are separate.

7. It has an amazing power of regeneration.

8. Development includes a pentacrinoid larva wih jointed stalk.

Habit and habitat:

It is cosmopolitan marine animal that occurs in shallow as well as deep waters. They are gregarious forms and feed on microscopic living organisms.

Distribution:

Antedon is worldwide in distribution, found in all seas. It is commonly found along Atlantic Coast.

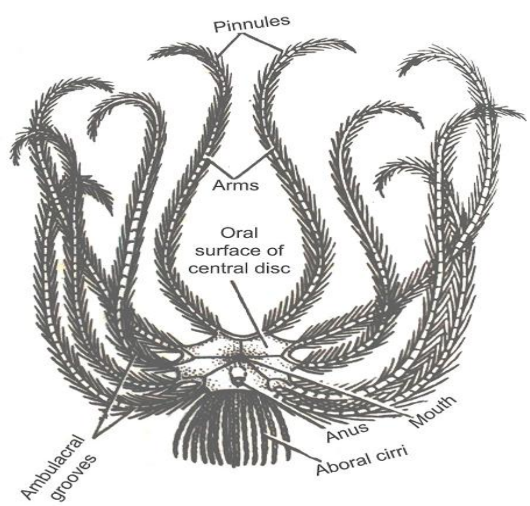


Fig 6 Antedon

9.3.5PEDICELLARIAE OF STAR FISH:

Comments:

1. Pedicellariae are whitish modified spine-like structures found scattered all over the body.

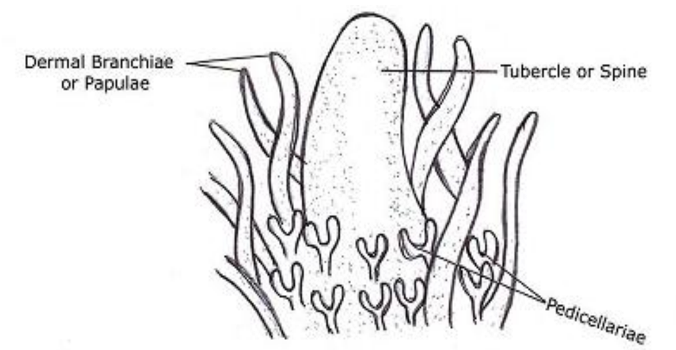
2. On the oral surface they are found attached to the bases of spines, while on the aboral surface they are found in the intervals between the spines.

3. There are two types of pedicellariae, viz., straight type and crossed type.

4. Each pedicellaria consists of a basilar piece and two jaws or valves or blades.

5. The valves or blades are movably articulated with the basilar piece and can be opened or closed on one another like the beak of a bird. The two valves or blades are operated by two pairs of adductor muscles and one pair of abductor muscles.

6. In some starfishes, the pedicellariae may help in capturing of small prey (Fig. 7).



Asterias (A) A cluster of pedicellarae, papulae and tubercle

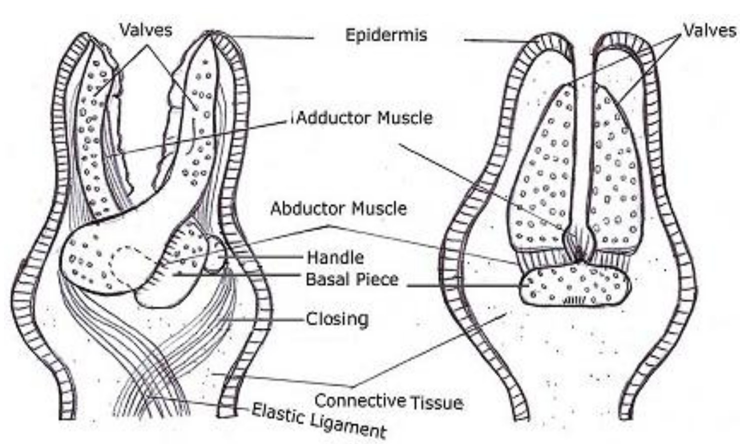


Fig. 7 Asterias (B) Crossed type pedicellae (C) Straight type pedicellarae

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UNIT 10: STUDY OF LIVING ANIMALS

Systematic Position

Phylum	Protozoa (Unicellular)
Sub-phylum	Sarcomastigophora (Cilia wanting, locomotion by pseudopodia)
Class	Rhizopodea (Locomotion and feeding by pseudopodia).
Order	Amoebida (Uninucleate)
Genus	*Amoeba*
Species	*proteus*

General study:-

Amoeba was first discovered by **Roesel Von Rosenhof** in 1775. It is regarded as the simplest of all animals, since its body consists of minute transparent asymmetrical specks of protoplasm having a nucleus but without permanent organelles. It is widely distributed and commonly found in the ooze or bottom mud in fresh water pools, ditches, lakes and slow streams, often in shallow water on the undersides of aquatic vegetation. The side of lotus ponds and the water trough are common source for their collection.

Amoeba is a unicellular microscopic animal and measures about 250 to 600 microns or 1/100 inches. It appears as an irregular colorless and translucent mass of protoplasm with finger- like projections from the body in all directions .These are called Pseudopodia. It keeps changing its shape in one direction and withdrawing in other direction. They are broad to cylindrical with blunt rounded tips and are composed of both ectoplasm and endoplasm. Its body is covered by very thin delicate plasma membrane called **plasmalemma** , these have adhesive properties and serve to bind animalcule to the substratum. Inside the plasmalemma is a dense mass of cytoplasm having several organelles .It is differentiated into an outer ectoplasm and an inner endoplasm .Ectoplasm is thin clear (non granular) and hyaline layer while endoplasm forms the main body completely surrounded by the ectoplasm. Endoplasm is made up of the outer stiff plasmagel and inner more fluid plasmasol. Endoplasmic organelles include a single conspicuous nucleus, a contractile vacuole which circulates with in endoplasm. Along with this, numerous food vacuoles are found scattered in the endoplasm. These are non-contractile and are of the different size

.Digestion of food takes place inside the food vacuole. Other organallies like E.R, Ribosome, Golgi body, mitochondria, lysosome are also found inside endoplasm.

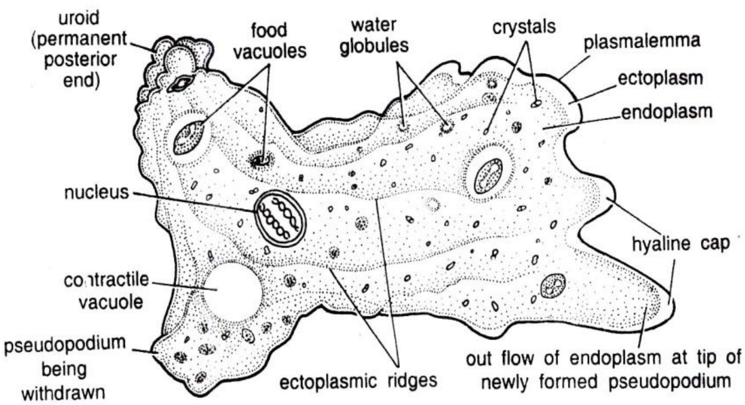

fig 10.1- Amoeba

Amoeba shows characteristics amoeboid movement by formation of finger like temporary processes, the pseudopodia called lobopodia due to their blunt finger like and rounded tips. These are formed as a result of forward movement of cytoplasm. Many theories have been put forward to explain the formation pseudopodia and the process of locomotion such as .Adhesion theory, Rolling movement theory, surface tension, contraction theory, sol-gel theory, walking movement theory, folding and unfolding theory, foundation zone contraction theory.

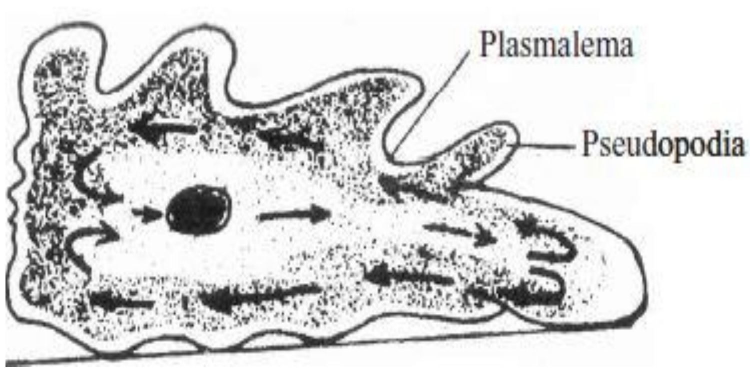

FIGURE 10.2 - MOVEMENT OF AMOEBA

Amoeba reproduces asexually by binary fission, multiple fission and by spore formation. Binary fission resulted the division of parent *Amoeba* into two daughters *Amoeba* by nuclear division followed by cytoplasmic division. Under adverse condition, *Amoeba* reproduces by multiple fission. Under favourable condition 200 spores are also formed in one *Amoeba* called sporulation. While few observers have also described temporary fusion between two *Amoeba*e called conjugation. *Amoeba* has a great power of regeneration. If it is cut into two or more pieces, accidently every piece having nucleus grows into a complete *Amoeba*.

Identifying features:

The animal is of irregular shape with simple or branched pseudopodia and its body is covered by a thin, delicate and permeable plasma membrane called as plasmalemma.

Special feature: It has unique phylogenetic significance and it is referred as immortal. Recently certain free living *Amoeba*e have been found to be pathogenic causing meningo encephalitis.

10.3.2 GENERAL STUDY OF *PARAMECIUM:-*

Systematic Position:-

Phylum	Protozoa	(Unicellular)
Sub-Phylum	Ciliophora	(Ciliary movement in all stages).
Class	Ciliata (Cilia present throughout life.)	
Sub Class	Euciliata (Cytopharynx, contractile vacuole, mega and micronucleus present	
Order	Holotricha	(Equal cilia.)
Sub-order	Trichostomata (Mouth leads into cytopharynx.)	
Family	Paramecidae (Oral groove present)	
Genus	*Paramecium*	
Species	*caudatum*	

GENERAL STUDY

Paramecium caudatum is commonly found in freshwater ponds, pools, ditches, streams, lakes, reservoirs and rivers. It is specially found in abundance in stagnant ponds rich in decaying matter, in organic infusions, and in the sewage water. *Paramecium caudatum* is a free-living organism and this species is worldwide in distribution. It is a microscopic organism and visible to the naked eyes as a minute elongate body. It appears light gray or white measuring commonly between 170 to 290 microns in length and may attain a length up to 300-350 microns. *P. caudatum* looks like the sole of a slipper or shoe, hence, the animals in commonly known as slipper animalcule. The body of the animal is asymmetrical in form showing a well defined oral or ventral surface and an aboral or dorsal one. The body is covered by a thin, double layered, elastic and firm pellicle made of gelatin. The pellicle holds the shape of the animal but is elastic enough to permit contractions. The entire body is

Covered with numerous, small, hair-like projections called cilia. When the cilia occur in longitudinal rows all over the body; then it is holotrichous, in which the body cilia are equal.

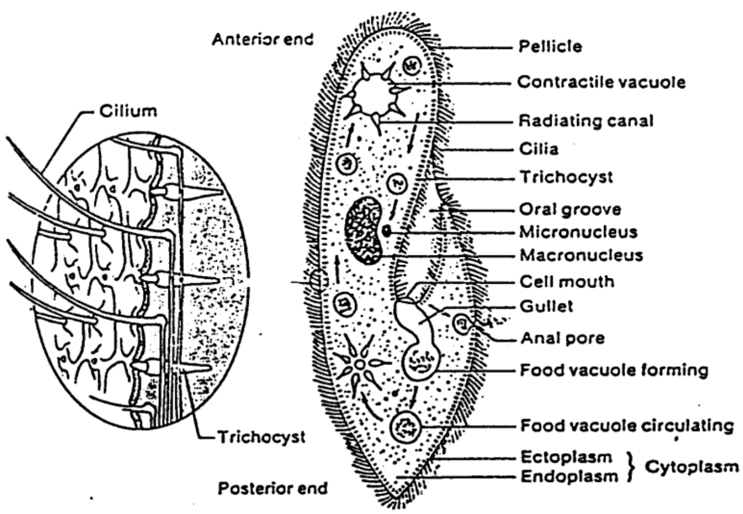

FIGURE 10.3 PARAMECIUM *CAUDATATUM*

The cilia rise from kinetosomes and from where arises a delicate cytoplasmic fibril called kinetodesma. Oral groove or peristome is situated on the ventrolateral side, which give the animal an asymmetrical appearance. The oral groove leads into a short conical funnel shaped depression called vestibule that leads directly into the cytostome. Extending directly from the cytostome toward the entire of the body is the wide cytopharynx that turns sharply towards the posterior side to become the slender tapering oesophagus.

In *Paramecium* nutrition is holozoic. The food comprises chiefly bacteria and minute Protozoa. During Cyclosis digestion occurs by enzymes secreted by protoplasm into the vacuoles. In digestion proteins are changed into amino acids, carbohydrates and fats. The undigested matter is egested through the cytopyge.

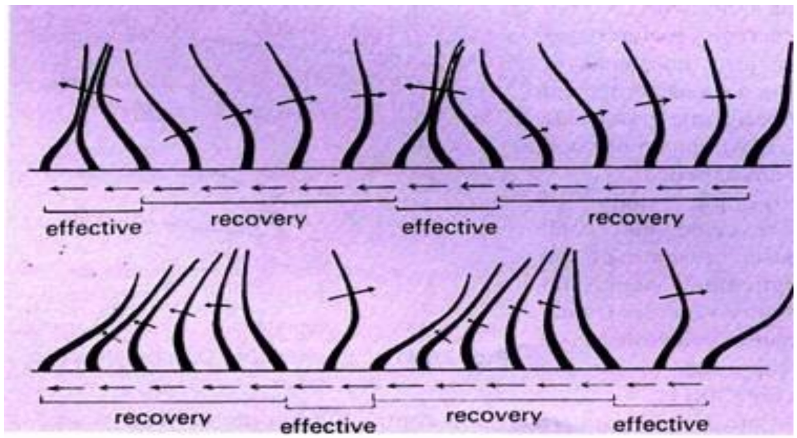

Fig. 10.4 Cilia indicating effective and recovery stroke

Generally Paramecia respond to chemical stimuli by means of avoiding reaction. Paramecia show an avoiding reaction when a temperature change occurs markedly above or below the optimal range (of 24^0 C to 28^0 C). However, when the light intensity is suddenly and sharply increased, a negative reaction is displayed .Paramecia exhibit an immediate negative response to Ultraviolet rays. Paramecia also respond to electric stimuli and positive rheotaxis.

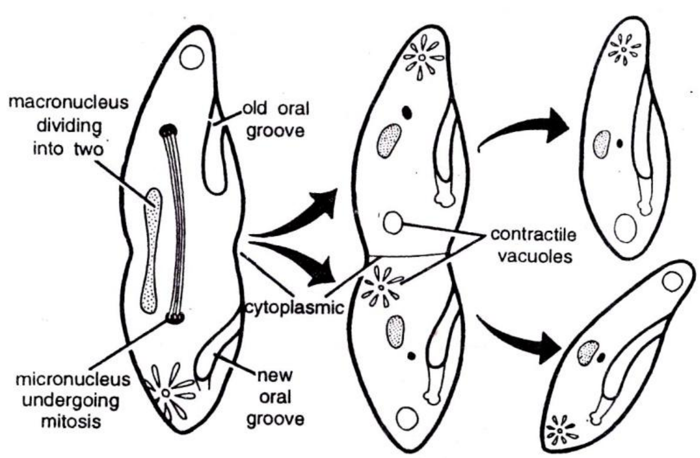

Figure 10.5 Paramecium showing binary fission

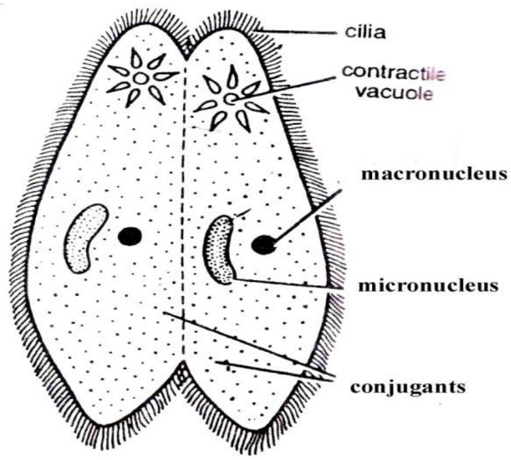

FIGURE 10.6 Paramecium*:* conjugation

Kappa particles:- In 1938, T.M. Sonneborn repored that some races (known as killers or killer strain of *Paramecium* produce a poisonous substance, called paramecin which is lethal to other individuals called sensitives. The paramecin is water soluble, diffusible and depends for its production upon some particles located in the cytoplasm of the *Paramecium* (killer strain). These particles are called kappa particles.

Identifying features: -

Since the animal contains slipper-shaped body and 2 contractile vacuoles which are star-shaped and has all above features, hence it is *Paramecium*.

Special features: -

Paramecium has great experimental value in cytogenetically studies. T.M. Sonneborn sensitive strain without Kappa particles. *P. aurelia* is taken as example to explain cytoplasmic inheritance.

10.3.3 General study of *Euglena*

Systematic position:-

Phylum	Protozoa (Unicellular)
Subphylum	Sarcomastigophora (Cilia absent, locomotion by pseudopodia)
Class	Phytomastigophora (Chromatophores present in majority)
Order	Euglenida (Larger forms with one or more flagella)

Genus *Euglena*

General study:-

Euglena is free-living and solitary. It occurs in stagnant water of ponds, pools and ditches with decaying nitrogenous organic matter. During rainy season it is so abundant that it imparts green colour to the water .Its body is fusiform or spindle-shaped with blunt anterior and pointed posterior end. Its size is microscopic varying from 53- 100µ. The blunt anterior end of the body has a funnel shaped depression. Its openings are called cytoplasm or mouth. It leads into a spherical reservoir through a short tube, the cytotpharynx or gullet–The two flagella arise from two tiny granules, the kinetosomes or blepheroplasts lying at the base of the reservoir. The body is enclosed in a tough but flexible pellicle or periplast that lies inside the plasma membrane and is formed of elastic fibrous protein. Due to toughness pellicle gives a definite form to the body. Its elasticity permits slight changes in body form. The cytoplasm is distinguished into:an outer thin, clear layer of ectoplasm, an inner granular and more fluid-like central mass of endoplasm.

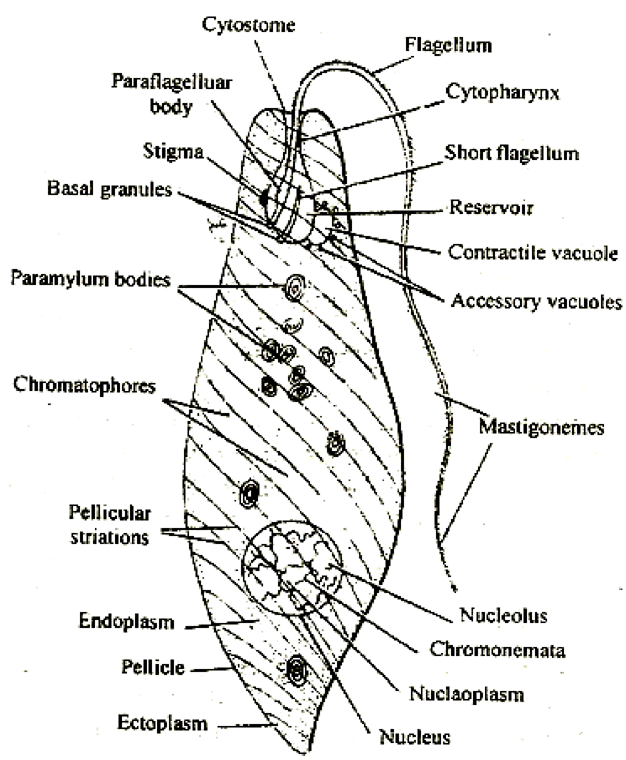

Fig. 10.7 Euglena

Its cytoplasmic inclusions are the chromatophores which are oval, disc-like, plate- like or rod-like chloroplasts. They possess chlorophyll a and b and help in the synthesis of food. The

Paramylon bodies which is a polysaccharide (B-1,3 glucon).There is a large contractile vacuole that lies on one side of the reservoir. An orange or red-coloured stigma or eye spot lies in contact with the reservoir that is formed of haematochrome and is sensitive to light.

Identifying feature: -

Euglena is a unique animal with floral and faunal mode of reproduction having chloroplast occurring in the form of 7-8 thick bodies surrounding a central paramylum granules and scattered pyrenoid bodies.

Special feature: -

The position of *Euglena* is still a debatable question as it is considered as an animal by zoologists and plant by botanists. It is included in the kingdom -Animalia on the basis of the following facts.

1. The proteinous nature of pellicle and absence of cellulose covering over the body.
2. Presence of contractile vacuole.
3. Presence of photosensitive stigma or eyespot.
4. Saprophytic and even holozoic mode of nutrition among some species of *Euglena*.
5. Movement from place to place
6. Longitudinal division of the body.

10.3.4 General Study of *Hydra:-*

Systematic position:-

Phylum- Coelenterata

Class- Hydrozoa

Order- Hydroidea

Suborder – Anthomedusae

Genus- *Hydra*

General study:-*Hydra* belongs to the most primitive Class Hydrozoa of Phylum coelenterata. It is simple in form and structure and serves as a good example for the study of coelenterate organization .*Hydra* one solitary, sessile, fresh water animals. They are cosmopolitan in distribution. They occur in lakes, ponds streams and seasonal ditches. They may be found attached to and hanging downward from underside of soiled object in water as leaves, sticks, stones weeds etc.

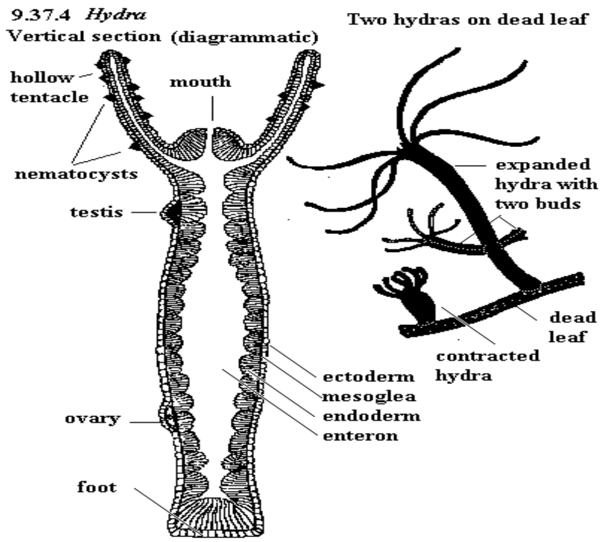

FIGURE 10.9 Vertical section of hydra

Hydra is a polyp like or polyploid coelentrate with a tubular or cylindrical body. Body symmetry is typically radial comprising an oral and aboral axis. Aboral end of the body is closed flattered called pedal disc or basal disc used for attachment to substratum. Distal or free end of the body is produced into hypostome having circular mouth. Hypostome bears 6-10 slender contractile and tubular thread like tentaclels that helps in feeding and locomotion. Other structure like testes occurs near the oral end while rounded ovary near aboral end.

Hydra is exclusively carnivorous. It feeds on insect larvae crustaceans (Cyclops Daphnia) and annelid worm. It can feed through nematocysts when an organism touches a tentacle; dozens of nematocysts are discharge into it at once. The penetrant puncture the victim & reject the paralyzing hyno toxin

Hydra reproduces asexually by budding and sexually by formation of gametes. *Hydra* has great power of regeneration (Abraham Trembley in 1745). If a living *Hydra* is cut into two, three or more pieces, each missing part grows and becomes a complete animal. Even it retains it polarity. **Tremble** observed that if head end of a *Hydra* is split into two it results into a Y-Shaped specimen or" two headed individual "By further "splitting" he succeeded in producing seven – headed Hydra.

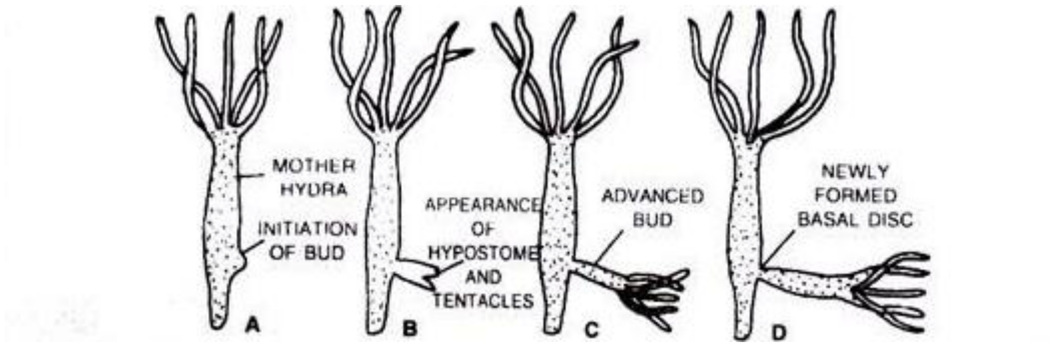

Fig. 10.11 Bud formation in Hydra

10.3.5- STUDY OF RECTAL CILIATES

The rectal ciliates are found in the rectum of frog are *Opalina, Balantidium, Nyctotherus* .To prepare the culture of these ciliates, take a living frog and chloroform it. Dissect and open its abdomen. Make a gentle cut up to cloaca carefully. Take out rectum and cut it and open it in 0.78percent normal saline in a small dish or watch glass. The ciliates coming out of rectum can be seen as moving objects. Observe living rectal ciliates under a stereoscopic binocular microscope.

To prepare the mount of rectal ciliates transfer the rectal ciliates on a clean slide. Apply a pin head Meyer's albumin on the slide and rub with fingers before transferring them into the slide. Albumin helps to stick protozoan by adding a drop or two of 90% alcohol. Let it become dry, then pass through descending series of alcohol as 90%,70% 50%,30% and distilled water. On the surface of the slide add a few drop of haemotoxylin for 1minute.Wash first with distilled water, then with tap water. If excess stains destain with acid water, wash with tap water, nuclei will stain blue. Then dehydrate in ascending series of 30%, 50%70% and 90%alcohol.Stain in eosin, wash and destain in 90% alcohol and keep in 100%.alcohol for 5min.Clear in xylene and mount on DPX. Let the slide become dry and observe under the microscope.